Medical Waste Management in Kanpur : Survey, Recommendations and Design of Related Equipment

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Certificate

This is to certify that the present work on **"Medical Waste Management in Kanpur : Survey, Recommendations and Design of Related Equipment"** is being submitted to the **Department of Chemical Engineering, Indian Institute of Technology Kanpur** in partial fulfilment of the requirements for the award of the degree of **Master of Technology** in **Chemical Engineering**.

This work has been carried out under my supervision, and has not been submitted elsewhere for a degree.

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ABSTRACT

Medical waste disposal is an important hazardous waste problem in Kanpur City having enormous potential to spread diseases. The health hazards associated with poor hospital waste management, disease transmission routes and waste management procedures are discussed in detail. A study of waste management has been done at four major hospitals of the city [LLR Hospital (Givt), Ursula Horsman Hospital (Govt), Madhuraj Nursing Home (Private) and Regency Hospital (Private)]. The study is concentrated with medical waste generation, collection, segregation, storage, transportation, treatment and disposal. Loopholes in waste management have been pointed out and recommendations have been provided to improve the disposal activity. Design of equipment autoclave and incinerator for medical waste has been done to treat the waste.

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B.Balakrishna Raju

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NOMENCLATURE

A_i	inside area, m^2
A_o	outside area, m^2
$C_{p,\,g}$	heat capacity of glass at constant pressure, kJ/kg-°C
$C_{p,\,ss}$	heat capacity of Stainless Steel at constant pressure, kJ/kg-°C
$C_{p,\,avg}$	avearage heat capacity, kJ/kg-°C
D	diametre of incinerator, m; d_I and d_o are inside and outside diametres of Autoclave, m
$\Delta H_{f,\,in}$	enthalpy of contaminated equipment in, kJ
$\Delta H_{f,}$ out	enthalpy of cleaned equipment out, kJ
$H_{steam,\,in}$	enthalpy of superheated steam in, kJ/kg
$\Delta H_{s,\,in}$	enthalpy of superheated steam in, kJ
$H_{s,\,out}$	enthalpy of saturated steam out, kJ/kg
$\Delta H_{s,\,out}$	enthalpy of saturated steam out, kJ
k	thermal conductivity of stainless steel, kcal/m-h-K
l	length of autoclave, m
L	length of incinerator, m
m_{load}	amount of waste, kg
m_{steam}	amount of steam, kg
Q	heat losses, kJ/hr
t	residence time, min
T_{amb}	ambient temperature, °C
T_{ref}	reference temperature, °C
$T_{w,\,inner}$	inner temperature, °C
Δx	thickness of autoclave, m
X	amount of Natural gas, kg
V	Volume, kg/m^3

CHAPTER-1

INTRODUCTION

Even as the modern world takes to newer and safer modes of medical waste disposal the government and private hospitals in our country are not following the safety norms. Most hospitals in the country generate infectious and hazardous wastes, which can affect the surrounding community by transferring disease causing pathogens into the environment, thus causing dangerous diseases. As the population growth is very rapid, the facilities in the hospitals are not upto the mark to treat the patients. It inturn, also increases the problems of waste management A good waste management programme in the hospitals mainly consists of collection, segregation, storage, transportation, treatment and disposal.

The magnitude of the problem of hospital waste was never a concern for the general public and social activists. Over the years a metamorphic change has occurred in the role of hospitals from that of housing the terminally ill and patients with communicable diseases, to that of a social institute providing preventive, promotive and curative care and also a centre of education, research and training.

Medical waste pose numerous potential health and safety hazards. The characteristic hazard of medical waste is its potential for transmitting infections. In today's highly modernized society, due to newer treatment techniques the various hazardous ingredients including corrosive chemicals, cytotoxic drugs, toxic chemicals, antibiotics and radioactive substances have become the part of hospital waste.

The waste also includes human anatomical wastes, animal waste, items saturated or dripped with blood and body fluids, waste sharps (needles, syringes, scalpels, etc.), highly infectious wastes, isolated wastes, discarded medical equipment, discarded

glassware, soiled wastes, liquid wastes, biotechnology wastes and autopsy wastes. Of the total waste mentioned above approximately 47% is biomedical waste, which is hazardous as it is contaminated with disease causing pathogens. All the waste will provide fertile environs for bacteria, viruses and other microbes. Pathogens like Salmonella, Vibrio, Escherichia, Hepatitis virus, Shigella are prevalent and active till these wastes are appropriately disposed, since they can be carried far by various agents.

The list of diseases caused due to improper disposal and treatment of hospital waste is endless but majority of them are fatal such as AIDS, Viral Hepatitis, Bronchitis, Gastroenteritis and other eye and skin related diseases. The high-risk areas in the hospital premises must be kept in proper maintenance to avoid the spread of these diseases.

Traditionally, a majority of medical wastes have been disposed of in landfills and some by incineration. In olden days the treatment for urban and rural people was provided in out patient clinics, nursing homes, small hospitals, sub-centres and at patients' houses. A substantial portion of waste material related to patient care, some of which is likely to be hazardous, is currently being generated in the small relatively unorganized sector of health care. Substantial number of persons also receive health care from practitioners of indigenous systems of medicine. Almost all these practitioners tend to dump the medical waste into nearest garbage dump. This also results in spread of infectious contamination.

In addition to health risks to patients and personnel, the impact of medical waste on human and the environment outside hospitals also a matter of concern. In particular, possible effects on the public, including aesthetic factors, and the risk of pollution of air, water and soil call for our attention. Disinfectants used in routine sanitary procedures, feces and urine from in-patient care, and most liquid wastes eventually find their way into the sewerage system. Similarly chemicals used in the hospitals are potential sources of pollution; mainly to water via the sewer system. Food waste from these establishment kitchens is also often disposed off through garbage grinders into sewers. Excessive solids can cause problems at sewage treatment plants.

The traditional method of disposal by landfill is facing new challenges because of the scarcity of landfill sites. Some landfills have been closed and many more will reach full capacity during this decade. Meanwhile developing new landfills has been difficult because of lack of available land, environmental risks and public opposition.

Awareness about the increased prevalence of hospital acquired infection bears testimony to the inadequacy or in appropriation of infection control measures. There is a need to evolve and implement strategies for safe and sustainable methods of disposal of waste materials generated at different sites in health care delivery systems. Now newer methods of treatment and procedures coupled with legislative requirements have made traditional medical waste management method obsolete. It is therefore essential that appropriate, affordable and safe methods of disposal of medical wastes is evolved and tested out; proven strategies for safe and sustainable methods of waste disposal at different sites of health care delivery can then be implemented vigorously. Awareness creation holds the key to success in this effort the general public, all health care seekers, health care providers, public health experts, policy makers and programme managers should be aware and should consistently discharge their duties to achieve this effect.

CHAPTER-2

AIMS & OBJECTIVES

2.1 AIMS

To study the waste management in four major hospitals of Kanpur city in order to assess its efficacy and shortcomings at various stages and also to design the equipment for treating the waste.

2.2 OBJECTIVES

1. Analyze and compare the actual hospital waste management system prevailing at big Government and Private hospitals in Kanpur, with a detailed study of the system to LLR Hospital.
2. Identify the loopholes at various stages.
3. Recommend measures for improvisation.
4. Design the equipment to treat the waste, suitable for the capacity of hospital.

2.3 METHODOLOGY

In order to meet the objectives mentioned above, the study was conducted in three phases:

Phase-1

Study of available literature and existing information, and their analysis. To have an insight into the various aspects of hospital waste management, a review of the available literature was carried out. This includes defining and characterizing the medical waste, its

generation, collection, transportation, treatment and disposal. The harmful effects of medical waste are also mentioned. The Bio-Medical waste rules issued by Government of India are have been discussed in detail.

Phase-2

Survey and spot inspection of four large hospitals of Kanpur. To collect necessary data, on prevalent hospital waste management practices, it was planned to study four Hospitals in Kanpur, which could fall under following categories:

1. The biggest hospital in the city, run by the Government of U.P, catering to the population of Kanpur and adjoining areas. Under this category Lala Lajapath Rai Hospital was chosen.
2. A large general hospital involving round the clock patient service under Government management. In this category Ursula Horsman Hospital was selected.
3. A large general hospital, also offering comfortable services and modern facilities, under private sector, under this the Regency Hospital was chosen.
4. A general hospital, offering health care in services, catering to fewer people, and under private control, under this Madhuraj Nursing Home was selected.

Selection of these hospitals was made in order to get an overall picture of waste management practices. Subsequently, a comparison between management in Government hospitals and Private hospitals has been made.

These four hospitals were visited on at least four to six different occasions each. Upon every visit, spot-inspection and observations were carried out with respect to the actual procedures of waste collection, packaging, storage, transport, treatment and disposal. If the incinerator facility was available it was visited and entire process of incineration, operation of controls, capacity and frequency of loading, safety measures taken, disposal of incinerated waste, etc., were carefully observed.

Phase-3

Collection of data and information was done, from personnel involved in the hospitals regarding waste management, through questionnaires, interviews, spot inspections and discussions. General information regarding the hospital, its administrative set up, levels of functioning, patient load etc., was collected from the Chief Medical Superintendent or his subordinates. Information regarding matters of waste handling, segregation, storage, transport, treatment and disposal was obtained by interviewing staff from the various departments involved. These included the administrative staff, housing staff, nursing staff and sanitary staff. Data regarding incineration facility in the hospitals was obtained from the chief of respective engineering departments.

A proforma of questionnaire was prepared and information regarding waste management practices was obtained from sweepers, sanitary workers, nurses and doctors. This clearly tells as to how much awareness was present among them about waste segregation and safe disposal of waste. All this information was noted down in the questionnaire. (Appendix-1).

CHAPTER-3

REVIEW OF LITERATURE

3.1 Definitions of Medical Waste

Despite the attention given to waste generated from health care services by the public, media, various levels of court and the government, the terms "Hospital waste", "Medical waste" and "Infectious waste" remain poorly defined. No standard universally accepted definitions for these terms exists, and there appear to be as many definitions in use as the number of group (WHO, state and central government boards, environmentalists) involved.

According to US Environmental Protection Agency[8]

The term "Hospital "waste refers to all waste, biological or non-biological that is discarded and not intended for further use.

The term "Medical" waste refers to materials generated as a result of patient diagnosis, treatment, or immunization of human beings or animals.

The term "Infectious" waste refers to that portion of medical waste that could transmit an infectious disease. Thus "Medical" waste is a subset of "Hospital" waste and "Infectious" waste is a subset of "Medical" waste.

For the first time in India, the Union Ministry of Environment and Forests (MEF) issued a notification in April 1995 to regulate disposal of hospital wastes. The notification called Bio-Medical waste rules[1] not only lays down the frame work for safe disposal of hospital waste but also regulates waste disposal technologies. The rules have been formulated after consultations with non-governmental organizations (NGOS), the medical community, citizen's groups and regulated bodies. Accordingly Bio-Medical waste means any solid, fluid, or liquid waste including its container and any immediate product, which is generated during the diagnosis, treatment or immunization of human beings or animals in research laboratories or in the production or testing of biologicals and the animal waste from slaughter houses.

3.2 Characterization of Medical Waste

The waste generated from the hospital can be broadly divided into non-hazardous, infectious and non-infectious but hazardous[13].

There are two broad categories of hazardous wastes:

1) Potentially infectious and
2) Potentially toxic

1) Potentially infectious waste from patient care includes:

a) Dressings, cotton, bandage, swabs, contaminated with blood and body fluids.

b) Laboratory wastes including cultures from medical and pathological laboratories, wastes from production of biologicals, laboratory glassware, discarded live and attenuated vaccines.

c) Instruments used in patient care- these range from diagnostic equipment such as endoscopes, syringes and needles, Pasteur pipettes, scalpel blades, blood vials, sharps and other instruments.

d) Potentially infected materials- blood and body parts, tissues, tumors, placentas, body organs which are removed during surgery.

e) Potentially infected animals- used in diagnostic or research studies.

2) Potentially toxic waste includes:

a) Chemical waste- these may be toxic, corrosive, flammable, reactive or genotoxic. Storage, transport, treatment and safe disposal of these requires special care.

b) Radioactive waste- these may be solids, liquids and gases used for analytical procedures, body organ imaging and tumor localization and treatment. This waste also treated carefully.

c) Pharmaceutical agents- these may enter hospital waste because there may be surplus stock, spillage or contamination or expire date exceeded, Special attention is required to see that they do not get recycled.

Hospital waste, in totality however, may be classified into eight main categories, as put forth by WHO[4]

1) General waste
2) Infectious waste
3) Pathological waste
4) Chemical waste
5) Radioactive waste
6) Sharp
7) Pharmaceutical waste
8) Pressurized waste

General Waste

It consists of all waste materials that are not regulated or defined as hazardous, special, or potentially dangerous and do not require special handling and disposal. These wastes are sometimes referred to as nonregulated medical waste. General waste[3] comprises a varying, heterogeneous mixture of paper goods, corrugated cardboard, plastics, food scraps, glassware, metals, packing material. noninfectious animal bedding, and other miscellaneous organics and inorganics.

Infectious Waste

It sometimes referred to as biomedical, biohazardous, contaminated, regulated, or, as they may be called, red-bag waste, and is usually generated in patient care and laboratory areas of health care facilities. Infectious waste[3] includes materials considered to be potential health hazards because of possible contamination with pathogenic microorganisms. This category includes cultures and stocks of infectious agents from laboratory work, waste from infected patients in isolated wards, waste from surgery and autopsies on patients with infectious diseases. And also waste that has been in contact with infected patients undergoing haemo-dialysis (operation theater equipment such as tubing and filters disposable towels, gowns, aprons, gloves, and laboratory coats) and waste that has been in contact with animals inoculated with infectious agent or suffering from an infectious disease.

Pathological Waste

It consists of tissues, organs, body parts body fluids, human foetuses and animal carcasses. The principal sources of pathological waste are clinical laboratories and the

surgery and obstetrics departments of hospitals. To burn this waste, heat must be applied to drive off the high moisture content.

Chemical Waste

It includes discarded solid, liquid and gaseous chemicals, for example from diagnostic and experimental work, and cleaning, house keeping and disinfecting procedures. This waste may be hazardous or nonhazardous. For the purpose of choosing the most appropriate waste handling method, hazardous chemical waste is considered to be waste that is toxic, corrosive (acids of pH<2 and bases of pH>12), flammable, reactive (explosive, water reactive, shock sensitive), genotoxic (carcinogenic, mutagenic, teratogenic or otherwise capable of altering genetic material), Nonhazardous chemical waste consists of chemicals other than those described above, such as sugars, amino acids and certain organic and inorganic salts.

Radioactive Waste

It includes solid, liquid and gaseous waste contaminated with radionuclides generated from in vitro analysis of body tissues and fluid, in vivo body organ imaging and tumor localization and therapeutic procedures.

Sharp Waste

It shall include discarded unused sharps and sharps used in animal or human patient care, medical research or clinical or pharmaceutical laboratories, hypodermic, intravenous or other medical needles, Pasteur pipettes, scalpel blades or blood vials, other types of broken or unbroken glass in contact with infectious agents.

Pharmaceutical Waste

It includes pharmaceutical products, drugs and chemicals that have been returned from wards, have been spilled, are outdated or contaminated, or are to be discarded because they are no longer required.

Pressurized Containers

It includes those used for demonstration or instructional purposes, containing innocuous or inert gas, and aerosol cans that may explode if incinerated or accidentally punctured.

3.3 Sources of Waste Generation Within a Hospital

Various wings and health care facilities within a hospital contribute to its waste generation capacities. The cumulative waste generated includes all forms of waste (General, Medical and Infectious) in varying proportions.

According to Alex S. Green[3], hospital areas generating wastes and their typical Products

Administration:

Paper goods

Obstetrics department including patients' rooms:

Soiled dressing; sponges; placentas; waste ampules, including silver nitrate capsules; needles and syringes. Disposables; masks; sanitary napkins and colostomy bags; enema units; diapers and underpads; gloves; etc.

Emergency and surgical departments, including patients' rooms:

Soiled dressings; sponges; body tissue, including amputations; waste ampules; needles and syringes; Levin tubes; drainage sets; colostomy bags; underpads; surgical gloves; etc.

Laboratory, pathology and autopsy rooms:

Contaminated glassware, indulging pipettes, petri dishes, specimen containers and specimen slides; body tissue; organs; bones.

Isolation rooms other than regular patients' rooms:

paper goods; dressings and bandages; leftover food; disposable masks; disposable salt and pepper shakers; etc.

Nursing stations:

Ampules; disposable needles and syringes; paper goods.

Service areas:

Cartons; crates; packing materials; paper goods; metal cans, drums, etc.; bottles, including food containers, solution bottles and pharmaceutical bottles; wastes form public and patient rooms, including paper goods, flowers etc.; waste food from central and floor kitchens; wastes form x-ray; discarded furniture; rags.

Dust and particulate matter from heating and ventilation equipment; soiled linens and uniforms; empty detergent, bleach and disinfectant containers.

Teaching and research areas:

Paper; bottles; dry rubbish; infectious wastes (mostly animal remains, including carcasses and organs); organs and limbs from surgery; ashes from crematories.

Food preparation areas:

Wooden crates; cardboard and plastic cartons containing food; food trimmings; cans; bottles; aluminum and plastic containers; paper try covers; disposable eating utensils; food wastes; etc.

3.4 Plausible Transmission Routes of Diseases

The principles of disease transmission suggests that infectious agents from medical waste will not be introduced into a host by the urinary tract, respiratory tract, or mucous membranes of the mouth, eyes or nose so long as standard health measures and proper personnel hygiene practices are adhered to. Similarly the potential for infection resulting from contact with non-sharp medical waste is virtually non existent[6]. For infection to occur from contact with non-sharp medical waste, each of the following events must take place in sequence.

1) The waste must contain viable human pathogen
2) An individual must come in direct contact with the infectious agents
3) An injury must occur following this contact, there by creating a portal of entry (open cut or scratches)
4) A sufficient number of viable infectious agents must enter a susceptible host via this portal of entry; then the agent causes infection by entering into the body.

There are many ways to prevent in contacting with medical waste by confining the waste into bags, boxes and containers at the site of waste generation.

The disease transmission mainly takes place through contaminated sharps, which can transmit the dangerous infectious agents upon contacting with them. Sharps have the capability to disrupt the skin's integrity and introduce infectious agents into the wound. In developing countries like India the transmission routes are not only by sharps but other ways also. The direct exposure to contaminated medical waste is a consequence of improper personal hygiene, lack of public hygiene concept, improper safety measures, inadequate sanitary measures and malpractice of some personnel.

3.5 Health Hazards Associated With Poor Hospital Waste Management

Improper management of waste generated at hospitals and other health care facilities, owing to their infectious nature, is capable of truly hazardous in nature to the environment. It is there by a matter of primary concern not only for personnel's directly involved in health care set-ups, but also amongst the masses. A need therefore arises to identify health and environmental hazards. At the same time it is important, for both practical and economic reasons, not to cause public alarm by looking for problems that do not exist or by exaggerating risks that are minimal or present also in other areas of everyday life. Of late, the rising concern over medical waste disposal has created a terror in administrative, legislative and social circles, sensationalized by the media. The public is concerned about medical waste as the probable risk for transmitting the HIV, HBV and other agents associated with blood born diseases and also about the emissions from incinerators that burn medical waste.

People liable to be exposed to health hazards associated with medical waste can be categorized into three broad categories[4]:

1) Patients' and personnel in health care establishments.
2) Personnel in organizations providing support services on a contract basis, such as laundries, incinerators and waste disposal sites.
3) Patients' and personnel involved in home care or primary care, such as dialysis.

Patients' at special risk from infections and other complications, resulting from exposure to microbial pathogens and sharps that may arise from breaks in the waste disposal system are;

1) Immuno suppressed patients' or those whose host defence mechanisms are otherwise altered(patients with AIDS belong to this category);
2) Patients' with bleeding or clotting disorders;
3) Drug abusers or addicts (who should be kept away from waste that contains needles, syringes or discarded drugs)

3.6 Hospital Waste Management

The management of hospital waste generated within a hospital lies with the hospital administration. Though in India in hospitals managing waste has given little priority, it is one of the most important activities every hospital should involve.

A good waste management programme in a hospital consists of

1) Employee's safety is the first and most important factor.
2) Preserving the hospital's good reputation with the community.
3) How to manage potentially infectious waste is to avoid legal intervention due to violation of waste management rules.
4) Lower cost of management is the other key factor. Since to treat the potentially infectious waste disposal is a costly process.

Medical waste management practices that should be employed in a hospital include strictly waste handling, treatment and disposal. Handling of the waste involves segregation, packaging, labeling and collection.

Segregation

Infectious waste must be segregated from other waste at the point of origin in the producing facility. Segregation at source is of great importance, because it allows special attention to be given to relatively small quantities of potentially hazardous waste that need special care at collection, storage and disposal. Poor segregation not only results in risk to hospital staff and public, but may also increase handling and disposal cost considerably. If source segregation is ensured, only a small amount of hazardous waste will require special treatment and this will considerably reduce the costs[15].

1) Trash (municipal waste) which includes kitchen garbage, office waste and anything else not contaminated by infectious, hazardous, or nuclear waste.
2) Infectious waste which includes human and animal body parts and fluids, bodily wastes, cultures and stock and anything contaminated by blood or body fluids (human and animal).
3) Hazardous Waste, which is any substance, listed or meets characteristics of hazardous waste.

Packaging and Labeling

According to United States Environmental Protection Agency (US-EPA)[8] recommendation, the segregation of infectious waste should occur at the point of origin. Containers of medical wastes must be properly labeled and marked and infectious waste containers must have the universal biohazard symbol on them.

Polyethylene bags are frequently used for containing bulk wastes, although they may have to be double-bagged with polypropylene bags that are resistant to autoclaving. Color-coded bags are frequently used to aid in the segregation and identification of infectious wastes. Usually *"Red "* coloured bag is used for human anatomical wastes, blood and body fluids, *"Orange"* coloured bag is used for animal and slaughter house wastes, *"Yellow"* coloured bag is used for waste sharps, highly infectious isolated wastes and discarded medicines, *"Black"* colour bag is used for incineration ash and non-infectious wastes for municipal dumps[1].

Needles (sharps) are of concern because of their infectious potential and the direct injury they can cause. The EPA recommends the use of puncture-proof containers for sharps. The previous practices of recapping or chopping needles are no longer being used because of the potential for worker injury.

Infectious wastes should be stored in areas that are disinfected regularly and that are maintained at appropriate temperatures, particularly if wastes are being stored prior to treatment. Such storage areas should be clearly identified with the biohazard symbol, and access should be limited. It is important to note the duration and temperature of strong infectious wastes due to their association and increases in rates of microbial growth and putrefaction.

Waste Collection

Collected wastes must be transferred from the point of generation to collection points for processing and appropriate disposal. The wastes should be placed in rigid or semi-rigid and leak-proof containers. The infectious waste management plan should include procedures to be used if liquid infectious wastes are spilled, plastic bags ruptured or other containers leak, or equipment fails.

In Hospitals, wastes are collected in one of three ways:

1) Plastic buckets
2) Open bins and
3) Waste Containers.

Treatment Of waste

Treatment ensures that the waste is completely modified from its original state, so that final disposal methods will be easier. The word treatment means a method, technique or process designated to change the physical, chemical, or biological characteristics or composition of any biomedical waste so as to render such waste non-hazardous to health and environment.

The treatment is of mainly two types:

1) Off-site Treatment and
2) Onsite treatment

1) Off-site Treatment

Off-site disposal of regulated medical wastes remains a visible option for smaller hospitals (less than 150 beds). However, some preliminary on-site processing such as compaction or hydropulping may be necessary prior to sending the waste off-size. Compaction reduces the total volume of solid wastes, often reducing transportation and disposal costs, but does not change the hazardous characteristics of the waste. However, it may not be economical if transportation and disposal costs are based upon weight rather than volume. Containers could also burst during compaction, releasing pathogens into the environment.

Hydropulping is a method[15] whereby the waste is ground in the presence of an oxidizing fluid, such as hypochlorite solution. The waste is fed into the top of a hammer mill, where it is pulped while being sprayed with the hypochlorite solution. The liquid is separated from the pulp and discharged directly into the sewer, unless local limits require additional pretreatment prior to discharge. The pulp can often be disposed of at a sanitary landfill. The advantage of hydropulping is that the waste can be rendered innocuous and reduced in size within the same system. Disadvantages are the added operating burden,

difficulty of controlling fugitive whether all organic matters and infectious organs from the waste have been destroyed.

2) On-site Treatment

On-site disposal is a feasible alternative for hospitals generating two tons per day or more of total solid waste. Common treatment techniques include incineration, steam sterilization and other methods. Although other options are available, incineration is the currently preferred method for on site treatment of hospital waste.

Incineration

Incineration is by far the best and most widely used and successful method of treating all the hospital hazardous waste including pathological waste, infectious waste and sharps. Incineration reduces the mass and volume by 90 - 95 %, and kills pathogens and converts combustible materials into noncombustible residue or ash[2]. This is a controlled burning process where in different waste types are subjected to time, temperature and turbulence, in varying combination and magnitude. The process takes place inside a specially designed furnace. All the waste treated in above conditions will become ash without smoke or odour.

The incineration process does not destroy matter, but it merely changes the chemical composition and toxicity of the substances burned. By transforming solid and liquid toxic wastes into gaseous emissions, incinerators actually increase the volume of waste by mixing it with air, and dispersing pollutants over land and water systems and into the atmosphere.

Since incineration is a versatile process, the *advantages*[10] are

1) The volume and weight of the waste are reduced to a fraction of its original size.
2) Waste reduction is immediate; it does not require long-term residence time.
3) Waste can be incinerated on-site, without having to be carted to a distant area.
4) Air discharges can be effectively controlled for minimal impact on the atmospheric environment.
5) The ash residue is usually nonputrescible, or sterile.

6) Technology exists to completely destroy even the most hazardous of materials in a complete and effective manner.
7) Incineration requires a relatively small disposal area, not the acres and acres required for lagoons or land burial.
8) By using heat recovery techniques the cost of operation can often be reduced or offset through the use of or sale of energy.

Incineration will not solve all waste problems. Some *disadvantages* include:

1) The capital cost is high.
2) Skilled operators are required.
3) Not all materials are incinerable, e.g., high aqueous wastes or noncombustible solids.
4) Some materials require supplemental fuel to attain mandated efficiencies of destruction.
5) Pollution control methods necessary.
6) Pollution to landfill with fly ash
7) Creation of hazardous chemicals. Formation of dioxins with increase of PVC chemcials.
8) Not suitable for radioactive waste.

Most waste incinerators are usually categorized according to the nature of the material, which they are designed to burn. There are eight main types of solid waste incinerators[10]

1. .Open-burning
2. Single-chamber incinerators
3. Teepee burners
4. Open-pit incinerators
5. Multiple chamber incinerators
6. Controlled air incinerators
7. Central station disposal
8. Rotary kiln incinerators.

Among above eight incinerators, controlled air incinerators and Rotary kiln incinerators are widely used.

Controlled Air (starved air) Incinerators

It is most widely used process because of lower particulate and toxic gas emissions. In this process less than the theoretical amount of air for complete combustion is supplied. Starved air incinerator consists of two major furnace components, a primary chamber and a secondary chamber. Waste is charged into the primary chamber, and a carefully controlled flow of air is introduced. Only enough air is provided to allow sufficient burning for heating to occur. Typically 70 to 80 percent of the stochiometric air requirement is introduced into the primary chamber, there by achieving very quiescent conditions as regard to gas entrainment[11]. The lower chamber operates at a temperature between 800°C-1500°C.

The off gas generated by this starved air reaction will contain combustibles, and this gas is burned in the second chamber, which is sized for sufficient residence time to totally destroy organics in the off gas. As in the primary chamber, a carefully controlled quantity of air is introduced into the second chamber, but in this case excess air, 140 to 200% of the off-gas stochiometric requirements is maintained to effect complete combustion.

Compared to other incineration methods, the airflow in the primary chamber, firing the waste is low in quantity and is low in velocity. The low velocity and near absence of turbulence of the waste result in minimal amounts of particulate carried along in the gas stream. Complete burning is accomplished in the secondary chamber, and the resulting exhaust gas is clean and practically free of particulate matter, i.e. smoke and soot[10].

They were originally developed for the destruction of trash, rubbish, a mixture of highly combustible waste such as paper, cardboard cartons, wooden scrap and combustible floor sweepings from healthcare centres. Now they are also used for human and animal remains, consisting of carcasses, organs and solid organic waste from hospitals, laboratories and animal slaughterhouses.

Rotary kiln Incinerator

The rotary kiln incinerator is a cylindrical shell lined with firebrick or other refractory and mounted with its axis at a slight angle from the horizontal. The general mechanism includes provisions for feeding, air injection, the kiln itself, an afterburner, and an ash collection system. The gas discharge tram the after burner is directed to an air emissions control system. An exhaust fan is provided within the emissions control system to draw gases from the kiln through a stack to the atmosphere[11].

The rotary kiln incinerator is generally applicable to the ultimate disposal of any form of combustible waste material, waste packs or drums and tar waste. It can incinerate combustible solids, liquids, gases and sludge.

Incineration is not suitable for all types of waste. Other modern alternative technologies are coming out for the treatment of medical waste. Alternative technologies are proposed to treat the medical waste, which is not incinerable. Ever tightening regulations on both in incinerator emissions and landfills have spurred the development of new technologies.

The alternative technologies for treating medical waste include

1) Steam sterilization
2) Chemical disinfection
3) Irradiation
4) Microwaving

Steam Sterilization

This process involves the treatment of medical waste with saturated steam at a sufficiently elevated temperature to kill infectious agents. This process is performed in an enclosed vessel, more commonly known as autoclave. The provision should be made to penetrate the steam into the waste so that complete killing of pathogens is assured[2]. The medical waste bags are heated at temperatures between 120°C-165°C for 30 to 70 minutes in chambers into which pressurized steam (15-80 Psi) is introduced. High density waste with relatively high water content inhibit direct steam penetration and require more time to decontaminate.

There are two effective models of autoclaves[9]:

1) Gravity displacement model.
2) Pre-vacuum model.

Gravity Displacement Model: In this model autoclave expels the chamber air through an exhaust valve as it fills with pressurized steam. This is less effective than the pre-vacuum model as some dilution is experienced in filling the chamber, which leads to less penetration of waste.

Pre-vacuum Model: In this model air is removed from the autoclave chamber prior to the addition of steam. The addition of pressurized steam elevates the temperature within the waste, sufficiently to kill the infectious wastes present.

Steam sterilization process is particularly applicable to laboratory cultures and items contaminated with known infectious organisms. It is also used for treating dressings, surgical instruments and supplies.

Waste with multiple hazards generally should not be steam decontaminated due to potential personnel exposure to toxic, radioactive or other hazardous chemicals. Anti-neoplastic drugs, toxic chemicals and chemicals that are volatilized by steam should not be autoclaved.

Advantages:

1) It has been used for many years in hospitals to sterilize instruments and containers and to treat small quantities of waste.
2) The waste can be properly sterilized if it is processed correctly

A *disadvantage* is that the waste does not change in appearance or volume after the sterilization, there could be a problem in gaining acceptance of the waste for landfilling.

Chemical Disinfection

This process involves contacting medical waste with a liquid chemical disinfectant. The wastes are initially ground to ensure that the chemical agent can penetrate the waste and aid in disposal of the residues. The materials then enter a bath where they are mixed with the disinfectants[2]. The resulting liquids including any remaining disinfectant agents are released to the sewer system, While the solid residues are drained of the disinfectant and disposed of in a landfill.

Common chemicals, which are used as disinfectants are chlorine compounds, alcohols, phenolic compounds, iodine compounds and formaldehyde solutions.

The characteristics[12] of disinfectants are

1) A disinfectant should kill a broad spectrum of bacteria within an appropriate time.

2) It should not be readily neutralized by the presence of such substances as body fluids or soaps.

3) It should not damage the object to be disinfected.

4) It should not be harmful to the humanbody at the concentration used.

5) It should be stable in liquid form.

6) It should be economical as well as effective at the concentration used.

This method is mainly used in disinfection of contaminated surfaces in the hospitals, medical equipment and pathological specimens. Also syringes and needles are disinfected before prior to sterilization.

Advantages:

1) This is a less costly process compared to other process.

2) More useful in the hospitals to stop spreading of pathological microorganisms.

Disadvantages:

1) This method does not completely remove the infectious agents as compared to sterilization.

2) Only minor kinds of wastes are treated.

Irradiation

Irradiation kills infectious agents, pathogenic bacteria and prevents replication. The principal forms of irradiation in use today include gamma irradiation, UV irradiation, electron beam irradiation and infrared irradiation. Only gamma irradiation is extensively used in the treatment of infectious hospital waste[2].

Gamma Irradiation: It is the bombardment of materials by electron particles. The most common material source is irradiation by Cobalt-60, a product in nuclear reactor. The rays have a penetration capacity of several meters, which is ideal for the treatment of waste sludge and packages.

In the treatment of wastes, the Cobalt-60 source is passed through a maze-like structure to the exposure chamber for subsequent treatment. After the required cycle time, the waste may be safely discharged without cooling. When using radioactive source material, it is recommended that the source strength be monitored because it diminishes with time. The exposure time may be varied by controlling the flow of wastewater or the speed of the conveyor belt[9].

Advantages:

1) The gamma irradiation has very low electricity requirements and does not heat treat material.

2) The treated wastewater does not require cooling prior to disposal.

Disadvantages:

1) It is a more costly process

2) There is a chance of personnel getting affected when treating the waste with gamma rays.

Microwaving

In this method at, the starting the waste is grinded and then microwaves are passed through them for disinfection and then the disposal of the treated material at the back end of the unit. This process unit works as a sterilizer since water is added during the grinding process and then microwave unit heats upto the water to steam[9].

Microwaves are defined as those with a frequency in between those of radio and infrared waves in the electromagnetic spectrum. When they used for medical waste treatment, they heat the preshredded and moistened waste to generate heat and release steam. It is the combination of the microwaves and moisture which is needed to generate the thermal energy to effectively treat the waste.

This method is only applicable to pathological waste such as body parts and animal carcasses. The temperature of the operation is usually carried around 90 to 100 degree centigrade to kill the infectious agents. It however depends upon the type of waste.

Advantages:

1) Since it is operated at low temperature, maintenance cost is less compared to radiation.

2) This is a very new technique and growth in this method is high.

Disadvantages:

1) Microwaves are limited to their ability to penetrate large and dense objects.

2) When handling with microwaves for treating of waste there is a chance of personnel being affected by the waves.

3) The volume and density of the waste is an important factor and affects the required treatment time.

Waste Disposal

As defined in the Notification by the Ministry of Environment and Forests, " disposal" means burial, discharge, deposit, dumping, land-filling or placing on land of any bio-medical waste. Presently, the methods of waste disposal in use are dumping, composting, sanitary landfill or controlled tipping[14].

Dumping: which is widely practiced, involves accumulating wastes at sites away from the general public domain. It is a most unsanitary method that creates public health hazards, nuisance and severe pollution of the environment. It needs to be outlawed.

Composting: Wasted food and other organics together with sludge are ideally suited for this method of disposal. The composted products can be further used as manure.

Sanitary landfill: It is an acceptable method for general and non-hazardous waste disposal. If the possibility of pollution of surface and ground water is eliminated, however acquisition of substantial land area for the process is a constraint.

3.7 Bio-Medical Waste Rules

Some salient features of Bio-Medical waste (Management & Handling) rules issued by the Ministry of Environment and Forests, Government of India in April, 1995 include[1]:

1) No hospital, nursing home or clinic with more than 30 beds or attending to more than 100 patients' to be without incinerators on its premises.
2) Small hospitals or clinics to set up common incinerator facilities.
3) Each veterinary institution, animal house or slaughterhouse generating waste more than 200 kg of bio-medical waste per day to install an incinerator on its premises.
4) Bio-medical wastes not to be stored more than 3 days.
5) All persons handling such wastes to ensure proper packaging and transportation of such wastes.
6) A ban on import or export of bio-medical wastes. No recycling to be permitted of any such waste except glassware.
7) Records to be maintained and annual returns to be filed.
8) No disposal to be allowed in municipal drains as it is currently is the practice.
9) Categories of bio-medical waste must be defined.
10) Types of containers for handling wastes defined, along with colour coding, labels and marks for identification.
11) All bio-medical wastes, which are not incinerable must be pretreated, disinfected and disposed off in an environmentally sound manner by an "authorized person" in sites defined by the "appropriate authority".
12) No person shall dump, discharge or dispose or cause to be dumped, buried, discharged or disposed any such waste in any place other than a site identified for the said purpose by the appropriate authority.
13) Every authorized person shall take all precautions and safety measures including the provision of protective clothing, masks, gloves, gum boots and such other protective gear as may be necessary for affording protection, to all the persons engaged in handling bio-medical wastes or exposed to such wastes. Washing and bathing facilities shall be provided in such premises.

14) The authorized person is the one who generates or operates a bio-medical facility and has been given authorization. The appropriate authority as nominated by the State Government could be the head of the directorate of health services, directorate of animal husbandry, veterinary sciences or state pollution control board.

15) All bio-medical waste generators including hospitals, nursing homes, clinical laboratories, blood banks required to ear mark specific areas with in their premises away from the general storage area for storage of bio-medical waste.

16) All plastics shall be disinfected and shredded and shall be disposed off in an environmentally sound manner or shall be recycled by reprocessing the shredded wastes.

17) Standards for Incinerators:

(A). ***Operating Standards***

1. Combustion efficiency (CE) shall be 99.9%.
2. Combustion efficiency is calculated as follows:

$$C.E = \frac{\%CO_2}{\%CO_2 + \%CO} * 100$$

3. The temperature of the primary chamber shall be in between 800°C-- 850°C.
4. The temperature of the secondary chamber gas residence time shall be at least one second at 1050°C and minimum 3% oxygen in the stack gas.
5. Waste gases entering particulate control device must be below 230°C to avoid temperatures in between 250°C to 400°C to prevent dioxin and furan formation.

(B). ***Emission Standards***

	Parameters	Concentration mg/m^3	
1.	Particulate Matter	100	(12% CO_2 correction)
2.	Carbon Monoxide	150	-do-
3.	Nitrogen Oxides	450	-do-
4.	HCl	50	-do-

5. Minimum stack height shall be 30 meters.

6. Suitably designed Venturi Scrubbers should be installed with the incinerator to achieve the above emission limits.
7. Necessary clearances and consents shall be obtained from the concerned pollution control board for setting up operation of the incinerator.
8. All wastes to be incinerated shall not be chemically treated with any chlorinated disinfectants. The waste sharps shall be shredded prior to incineration.

Various articles regarding medical waste management and disposal published in leading News papers are attached in Appendix-II.

CHAPTER-4

OBSERVATIONS AND ANALYSIS OF WASTE MANAGEMENT AT FOUR MAJOR HOSPITALS IN KANPUR

4.1 Lala Lajapat Rai Hospital

This is the oldest government hospital in the city. It is located on the G.T. road, opposite to Medical College, Kanpur. The main building is shown in **Fig 4.1a**. The hospital is the biggest in the city with total bed strength of 1055. The hospital provides round the clock emergency services to the incoming patients. On an average, the hospital has a daily OPD attendance of about 1500, out of which 150 to 170 utilize the emergency services and remaining are outdoor patients.

As per the annual reports considered between 1995-97, about 13,100 people per year were admitted as indoor patients' and about 4,18,000 were attended to as outdoor patients'. On an average about 60 minor operations and 20 major operations are performed daily. The patient care services are provided by the highly qualified doctors and other hospital staff. The total hospital staff number 1000, among which 70 are senior doctors 250 are junior doctors, who help the senior doctors. There are also 300 nurses, 100 administrative staff, and remaining include 3rd and 4th category employees like safai karmacharis, ward boys and sweepers.

Waste management in the hospital is being dealt by house keeping staff. The staff includes sweepers and safai karmacharis. They are assigned to each department and they perform round the clock duties. The workers attend the shifts once in the morning and once in the evening. They are under supervision of the house keeping department committee.

In LLR hospital the waste management process consists of waste generation, collection, transportation, storage, treatment and disposal.

4.1.1 Waste Generation

a) The hospital consists of different wards like general, surgical, medical, orthopaedics, emergency, new medical male and female wards. It also has kitchens, laundries, office rooms and storage rooms.

b) The waste from all these departments includes infectious, non-infectious and hazardous waste.

c) The infectious waste contains treated cotton bandages, blood, syringes, needles, eurosec bags, body parts and fluids, tissues, tumors and ampules. The non-infectious wastes consist of kitchen waste, sanitary waste, paper waste from administrative sections, cardboards, etc. The hazardous waste includes laboratory waste, cultures and stocks, discarded medicines and chemicals from laboratories.

d) Approximately 1100 kg of waste is produced daily from 1055 beds. This accounts for an average of 1.05 kg /bed/day.

e) The wastes generated in different wards are different in quality and quantity. During the period under observation, the following data were obtained in different wards:

Table 4.1

Ward No/Nos	Ward name	No of beds	Amount of waste per day(kg)	Amount of waste per bed per day (kg).
1 & 2	General (surgical)	107	120	1.12
3 & 4	Medicine (ortho)	55	70	1.27
16	New medical (male)	42	60	1.42
100	Medicine (emergency)	180	250	1.38
11 & 12	Ortho and surgery	86	120	1.4
17 & 18	Paying	42	50	1.2

Containers with a capacity of 50 kg are used for collecting the waste generated. Besides these listed above, the waste comes from some other wards like intensive care unit, maternity ward and children ward.

4.1.2 Waste Collection

Waste collection is an important aspect in waste management.

a) In LLR hospital for each ward separate garbage removal members have been allotted.
b) The frequency of collection in each department was usually twice a day, once in the morning and once in the evening.
c) For waste collection, workers are provided with plastic buckets and drums.
d) There is no colour coding of waste buckets, so the persons involved in waste collection do not know the break-up of infectious and non-infectious, hazardous and non-hazardous waste. They simply collect all the wastes into a plastic bucket, then transport it to storage area or incineration site. Each bucket has a capacity of 50 kg.
e) For the waste collection, upon observing the workers, it is found that they are not provided with rubber gloves, face masks and boots. They are simply collecting the waste with bare hands. This can cause cuts, especially when they come across with infected sharps and needles, leading to very serious disease like HIV infection.
f) The authorities' report states that there exists a special immunization programme for all the waste collecting persons in order to prevent the spreading of infectious diseases. But the workers said that they did not undergo any such programme.

4.1.3 Waste Segregation

a) There are no criteria for segregating different types of waste in the hospital. All the waste in each department or ward is collected into same plastic buckets.
b) According to nurses, some of the recyclable wastes like plastic bags, glass bottles and other plastic material are sometimes taken away by the relatives of the patients'.
c) Nurses also said that at times, there were even thefts of recyclable items, especially when the nurses and ward boys are away for lunch.
d) In some wards like surgical and emergency wards, waste is thrown outside the departments without treating.

4.1.4 Waste Storage

As far as waste storage is concerned for this hospital, the following observations were made:

a) There is no separate system for storage. All the waste from each ward and department is carried to an open area containing no boundary (shown in **Fig 4.1.3a**).

b) According to the officials, duration of storage is 48 hours, but upon enquiring the residential colony people, adjacent to the hospital, they said that some times the waste was stored for more than a week, before it was picked up by the Nagar Mahapalika Van.

c) The increased amount of waste is occupying as much as 100 square metre in the hospital site.

4.1.5 Waste Transportation

a) Transportation of waste from collection site to disposal site and incinerator site is done by safai karmacharis, for this they use trolleys.

b) Not all wards have trolleys. In general wards and maternity wards the safai karmacharis simply lift the waste buckets and take them to the storage area or incineration site.

c) For transporting the waste there is no fixed route, all the waste is carried through normal existing ways and sometimes spillage of waste occurs enroute.

d) The waste from storage area is taken outside the city by a Nagar Mahapalika Van, which is used for the purpose of collecting waste all over the city.

e) The van is supposed to come for five days in a week (except on Saturdays and Sundays) according to the officials, but upon spot inspection and observation it has been found that Van comes only once in 6 or 7 days. This is confirmed by the fact, that the amount of waste stored increased day by day and was found to occupy larger and larger space.

4.1.6 Waste Treatment

Treatment ensures complete destruction of infectious agents present in the waste. In LLR hospital, the treatment of waste is done by chemical disinfection, steam sterilization and incineration.

Chemical Disinfection

Chemical disinfection is carried out in operation theatres, emergency wings and departments, which can spread diseases. All these wards are bleached by a chemical disinfectant twice a day in order to remove the infectious agents which can contaminate the surfaces and equipment. No special treatment system is available to treat the solid or liquid waste by disinfection.

Steam Sterilization

Steam sterilization equipment is used to decontaminate the medical and surgical equipment, after performing the operations. All the operation equipment, linen, face masks, caps and gloves are steam sterilized in an autoclave. All these items are kept in a drum and introduced into autoclave for treatment upto 20 minutes.

Incineration

a) LLR hospital has installed an incinerator in December 1997.

b) The capacity of the incinerator is 10 kg/hr. It consists of two drums, each with a capacity of 5 kg/hr. The operating temperature range from 697°C to 850°C. It also contains air pollution abatement equipment. The chimney height is approximately 30 feet above the base. The incinerator is operated using electric supply.

c) The location of the incinerator is inside the hospital. It is installed in a toilet attached to the surgical ward (O.T) (shown in **Fig 4.1. 6a**).

d) It is found that, when the waste is treated, incinerator emits toxic gases from the chimney. If the wind blows in the direction of surgical ward and O.T, the smoke containing toxic gases diffuses into these wards, affecting the people there. According to the incinerator operator, this has been happening many times but no action has been taken. Upon asking the operator whether he informed the officials, he said that they ignored his information. Upon asking some doctors, who worked in O.T, it was found that, they also did not know the harmful effects of the toxic gas emissions (shown in **Fig 4.1.6b**).

e) The waste treated in the incinerator mainly comes from operation theatres, emergency wards, intensive care units and maternity wards. It consists of human anatomical waste, body parts, bandages, pathological waste and other infectious waste. The waste fed into the incinerator is shown in **Fig 4.1.6c.**

f) The waste is brought to the incinerator in the afternoon at around 12'o clock because all the operations are usually performed in the morning. To bring the waste plastic buckets are used.

g) The incinerator is operated twice in the afternoon, for 70 to 80 minutes. Each time 10 kg of waste is incinerated. It is found that due to release of heat from materials like foam of mattress, cotton and bandages, the temperature in the chamber often exceeded the maximum set limits leading to the damage of incinerator cover. Upon spot inspection, it is also found that the toxic gases, which are to be let out through the chimney also come out from the incinerator cover. Due to this the entire area gets filled with toxic gases generating foul smell within 40 minutes.

h) The air pollution abatement equipment attached to incinerator consists of a water scrubber, which is designed to absorb toxic gases containing particulate matter of maximum concentration and let the gases below the dangerous level to the atmosphere. It is found that water scrubber also emits some gases as it is not sealed properly (shown in **Fig 4.1.6d**). The water is fed to the unit once in two days, into a 100-litre tank and discharged after incineration is completed.

i) The person involved in incinerator handling is not supplied with facemasks and boots, he has been given only hand gloves. Whenever he opens the door after incineration, he gets affected by the dangerous toxic gases, which evolve from incinerator as said earlier. The operator said that he had already faced some health problems like vomitings, fever and cough after inhaling toxic gases.

j) The operator also said that it was very difficult to operate the incinerator at a temperature of around 700°C. There is also no provision to show whether the waste is completely incinerated or not. If unknowingly he opens the door at that high temperature, at times, the waste material is still burning and high intensity fumes are evolved. The incinerator takes very long time to cool down. The operator has not been given any training regarding safe handling of the incinerator.

k) There is no facility at the incinerator site for the storage of the waste, they simply keep the waste outside the room and it decomposes there affecting the passers by seriously. The other problem is that if no person is present at that site, then dogs enter and drag away the waste into the hospital premises. The operator informed the author about this.

l) The incinerated ash (shown in **Fig 4.1.6e**) is disposed off besides the incinerator room. It is not being carried to the disposal site.

m) Two safai karmacharis are also employed at the incinerator site. They do their duties in shift systems.

n) No security is provided at the incinerator site.

4.1.7 Waste Disposal

The waste disposal at LLR hospital is not given much importance. From spot inspections it is observed that;

a) Entire waste from the hospital is disposed off beside the residential colonies and patient wards.

b) Some types of waste is burned at the disposal site instead of being taken to the incineration.

c) There is no boundary for the disposal site and waste occupied more than 100 sq. metres.

d) Rag pickers are found working throughout the day, collecting disposable syringes and other recyclable goods from the disposal site. Upon asking them they say that they sell these goods to contractors in Begum Gunj. The contractors usually repack them without proper treatment. This can cause spreading of dangerous diseases. The ragpicker with the items, which he has collected is shown in **Fig 4.1.7a.**

e) From the disposal site waste is transported by a Nagar Mahapalika Van to outside the Kanpur City.

f) Waste from kitchens and other liquid effluents will find their way into the underground sewage system through drainage pipes.

Questionnaire regarding waste management is attached in Appendix-I

Waste Management Photographs of LLR Hospital

Fig 4.1a Main building of the hospital

Fig 4.1.4a Waste storage site within the hospital

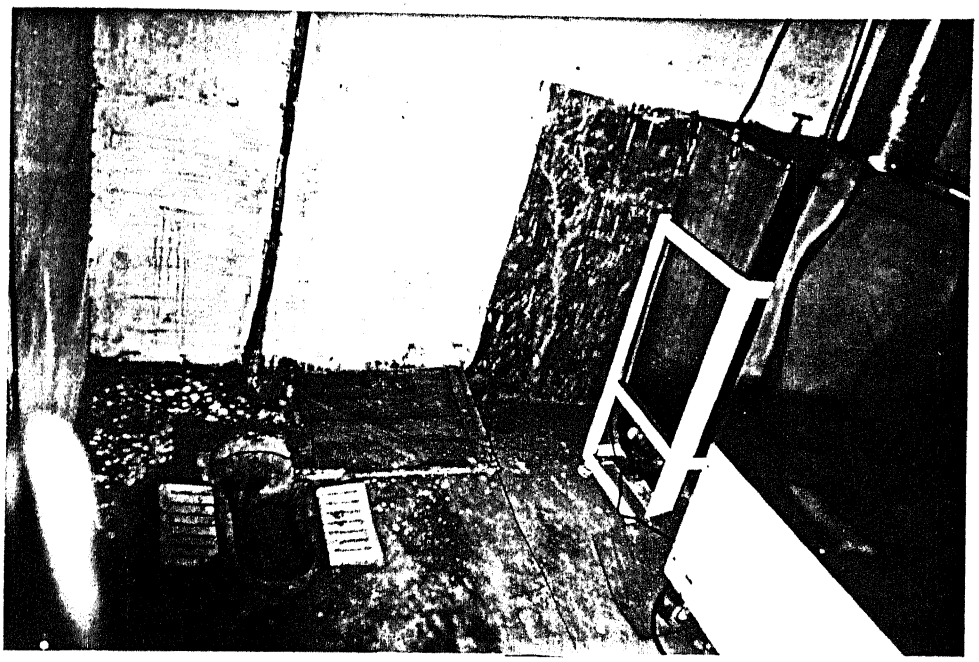

Fig 4.1.6a Incinerator installed in a toilet

Fig 4.1.6b Incinerator stack besides the surgery ward

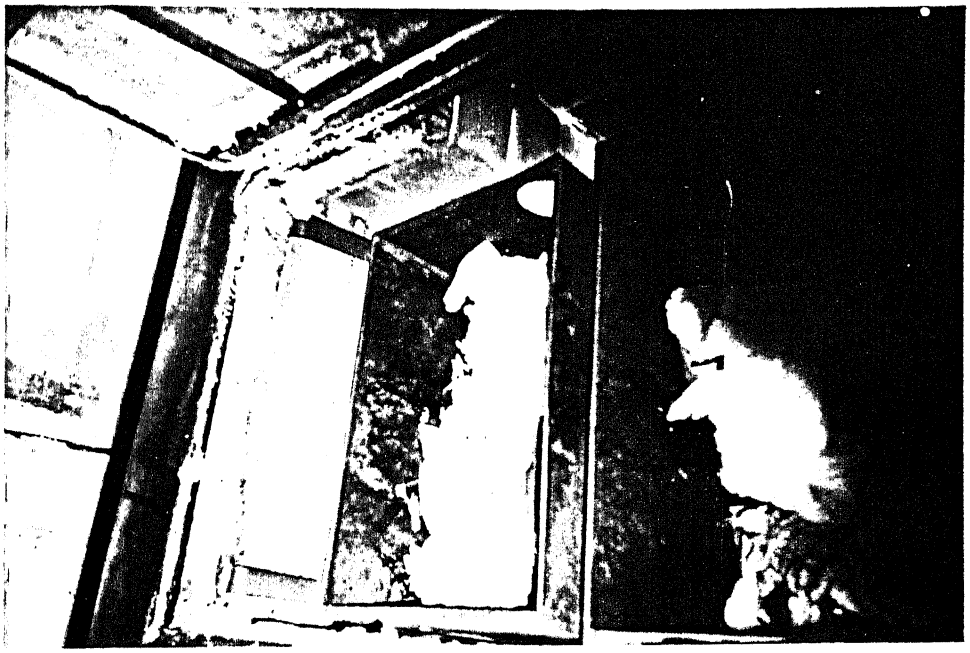

Fig 4.1.6c The waste items fed into the incinerator drums

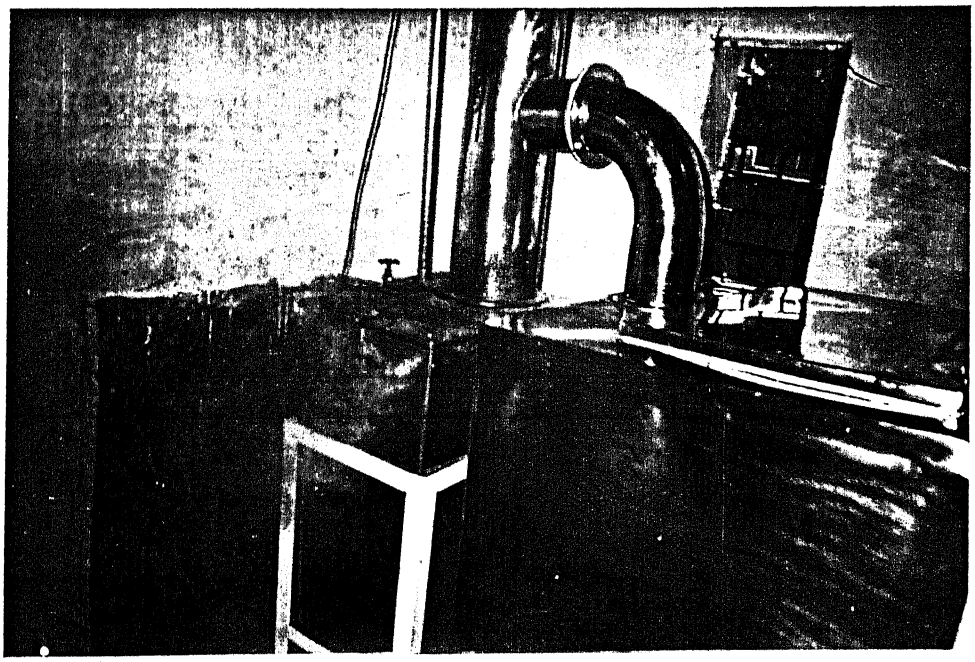

Fig 4.1.6d Toxic gases coming out of water scrubber

Fig 4.1.6e Incinerated ash disposed off besides the incinerator room

Fig 4.1.7a Ragpicker with the items, which he has collected

4.2 Ursula Horsman Hospital

This is the second largest government hospital in the city established on 26th Feb. 1937. The location of the hospital is at Bada Chowrah, city's main shopping centre. The main building of the hospital is shown in Fig 4.2a. The total hospital staff is around 450. They provide health care facilities round the clock. Among them, 70 are doctors, 100 are nurses and 200 are type 3 and type 4 category consisting of sweepers, ward boys and sanitary workers.

The hospital contains 13 wards, with a total bed capacity of 416. The different wards are medical, surgical, pathology, emergency, private, paying, eye section, ear section, burn unit and cardiology. Among these 8 are general wards, 2 are emergency wards, 2 are private wards and one is burn ward.

The waste management in the hospital is not given any special priority, as there is no separate department to deal with the problem. All the sweepers of the respective departments are involved in the waste management.

4.2.1 Waste Generation

The total waste generated in the hospital is approximately 550 kg/day out of 416 beds. The average waste per bed per day is 1.3 kg. The waste consists of pathological waste, sharps, glasware, plastics, human anatomical waste, body parts and fluids, tissues, wasted food and office trash. The waste generated from different wards is shown below.

Table 4.2:

Ward No	Ward name	No of beds	Amount of waste per day(kg)	Amount of waste per bed per day(kg)
1	Paying	27	30	1.1
2	Private	18	20	1.1
3	Emergency	66	100	1.5
4	Medical	73	120	1.6
5	Surgical	166	200	1.2
6	Children	18	30	1.7

From the remaining wards very small amount of waste is generated. The quantity of waste in each ward has been determined by asking the sweepers. They use a 40 kg plastic bucket to collect the waste. Depending upon number of times they collect a bucket full of waste, amount of waste has been noted down.

4.2.2 Waste Collection

For waste collection, in each ward, sweepers are employed. They are provided with plastic buckets and drums. There is no separate group for waste collection. The sweepers are not provided with hand gloves, boots and facemasks. The frequency of collection is twice a day, in the morning and in the evening.

4.2.3 Waste Segregation

Segregation of hospital waste into infectious, non-infectious and hazardous are not initiated at the site of generation. All the waste is dumped into plastic buckets. There is no colour coding of plastic buckets. The officials have said that of the total waste upto 15% is infectious and remaining is non-infectious. The waste from burn ward is thrown besides the same ward (shown in **Fig 4.2.3a**). The sweepers are not carrying the waste to storage site. Upon observation in the pathology lab it is found that after conducting the experiments, empty bottles containing infectious agents are just thrown away besides the building.

4.2.4 Waste Storage

There is no separate storage area provided for the waste. The disposal site is used as storage site. The storage site is away from all the wards; it is located at the compound wall of hospital adjacent to the main road. The duration of storage is from six to seven days. As there is no incinerator in the hospital, the waste is kept at the storage site only.

4.2.5 Waste Transportation

For the transportation of the waste from different wards to the disposal site trolleys are used. Surgical, emergency and two medical wards are provided with trolleys;

from the remaining wards the sweepers carry all the waste to the disposal site with buckets. Some sweepers complained that it was very difficult to bring the waste from upstair-wards. There is no fixed route for waste transportation. The waste from disposal site is transported by a Nagar Mahapalika Van once in a week according to the shopkeepers at that site.

4.2.6 Waste Treatment

The principal methods of waste treatment are steam sterilization and chemical disinfection. These two methods are also limited to certain types of waste.

Steam sterilization is used in the operation theatres for sterilizing the operation equipment like medical and surgical instruments, facemasks, linen and hand gloves. Sterilization unit works in the afternoon after the operations are completed. In some patient wards syringes and needles are sterilized to reuse them.

Chemical disinfection is used only in operation theatres and laboratories to disinfect contaminated surfaces and medical equipment.

This hospital does not have incineration facility; they have ordered for a 20kg/hr capacity incinerator for treatment. The medical superintendent said that they are going to get it in 3 months. Upon asking where will they install the incinerator, he said that separate provision had been made for locating it, away from the patient wards.

4.2.7 Waste Disposal

The waste is disposed off away from the patient wards, but near the main road. The disposal site does not have any boundary, if the waste is not transported within one or two days entire waste comes on to the main road and passers by get affected by the foul smell coming from the waste (shown in **Fig 4.2.7a**). The shopkeepers on the footpath complained that the Nagar Mahapalika Van comes once in a week to transport the waste for final disposal outside the Kanpur City. No training is given to staff regarding safe handling and disposal of waste. The persons are also not given immunization vaccines to withstand the diseases from the waste.

Questionnaire regarding waste management is attached in Appendix-I

Waste Management Photographs of Ursula Hospital

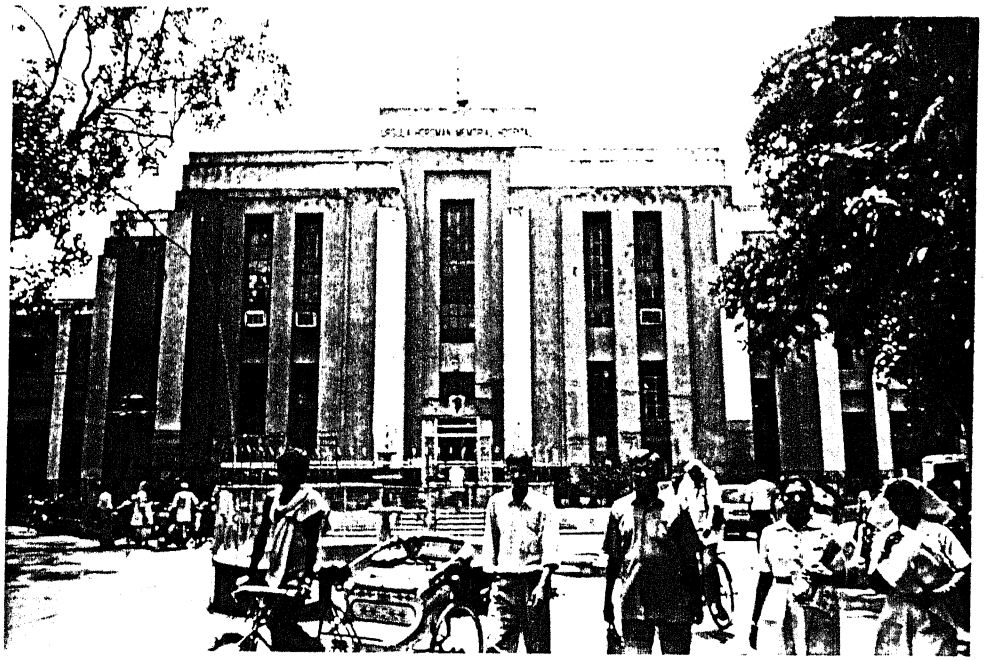

Fig 4.2a Main building of the hospital

Fig 4.2.7a Waste disposal site near the main road

Fig 4.2.3a Waste disposed off besides the burn ward

4.3 Madhuraj Nursing Home

This is a premiere hospital in the city located in Swaroopnagar under private management (shown in **Fig 4.3a**). It was established in 1984, and is equipped with modern technology options in patient care diagnosis and treatment. The total hospital staff is around 150 in which 8 are senior doctors, 6 are junior doctors, 60 are nurses and remaining are ward boys, and sweepers. Two men are employed to deal with the waste management.

The hospital consists of three floors and equipped with sophisticated medical facilities such as orthopaedic unit, dialysis unit, neonatal surgery ward, intensive care units, operation theatres, pathology, etc. The hospital at present contains around 80 beds. The daily OPD attendance is around 50 to 60. Different types of wards are present like general, deluxe and super deluxe wards and sweepers are allotted to clean the rooms.

The waste management in the hospital is under the supervision of two persons. All the sweepers in the hospital are working under these two persons. There is no separate housekeeping department to look over the issue.

4.3.1 Waste Generation

The total amount of waste generated is approximately 140 kg/day. This accounts for around 1.75 kg/bed/day. Out of 140 kg, approximately 30 kg is infectious, 80 kg is non-infectious but hazardous and remaining amount of waste is recyclable and non-hazardous. The waste from different departments mainly consists of human anatomical waste, blood and body parts, body fluids, disposable needles, syringes, bandages, cotton, urobags, discarded medicines, plastic bags, bottles and non medical waste such as paper, card board and eatables. The sources of waste are from operation theatres, nursing stations, emergency wards, general ward, pathological ward and also from office rooms. The maximum amount of waste comes from the third floor as it contains maximum number of beds. From first and second floors also waste is generated but is less in quantity compared to the third floor.

4.3.2 Waste Collection

For waste collection sweepers are employed in each ward. They are provided with uniform. The sweepers collect the waste in a 25kg plastic bucket. Each floor is separately provided with buckets. The frequency of collection is usually more than twice. There are 40 sweepers in the hospital and they do the duties in a shift system covering the whole day. According to the officials the sweepers are provided with hand gloves, face masks and boots. But upon spot inspection it has been found that a woman sweeper in the operation theatre was collecting the infectious waste with bare hands, she was also without face masks and boots. Many sweepers complained that they did not have protective gear.

4.3.3 Waste Segregation

There are no segregation criteria in the hospital as all the waste is dumped into plastic buckets. It is found that operation theatre waste after collection is transferred into a plastic bucket, which is used for general waste. There is no colour coding of the plastic buckets. In each floor same type of buckets are used. There is no separation of infectious, non-infectious and hazardous waste. Though the amount of infectious waste is less compared to general waste separation should be done at the site of origin itself

4.3.4 Waste Storage

Waste storage in this hospital is upto the standard as observed. All the waste from different wards is transported to the storage site, which is in the ground floor away from the patient wards. The storage site has a gate (shown in **Fig 4.3.4a**) and inside that trolleys are kept. The waste is stored in the trolleys (shown in **Fig 4.3.4b**) for one day and then it is transported to the municipal site for disposal.

4.3.5 Waste Transportation

For the waste transportation there is no fixed route in the hospital. Although lift is available it is used for carrying people. The sweepers after collecting the waste transport the waste through the main way. From the storage site waste is transported by trolleys to

the municipal site, from there Nagar Mahapalika Van collects the waste and transports it to the outside of Kanpur City.

4.3.6 Waste Treatment and Disposal

As far as treatment of the waste is considered only steam sterilization and chemical disinfection methods are employed.

Steam Sterilization

In this method the waste material i.e. medical and surgical instruments used in operation theatres, gloves, face masks, caps and linens are kept in a steel can and then introduced into an autoclave. The autoclave operates at a temperature of 120°C and at a working pressure of 1.2 kg/cm^2. The water converts into steam at these conditions and passes through the chamber and kills the pathogens and infectious agents. This process is done for 15 to 25 minutes.

Chemical Disinfection

This method is used to decontaminate the surfaces occupied by pathogens and infectious agents. All the wards are disinfected once every 3 hours to keep them clean. For disinfection, chlorine compounds are used.

The hospital does not have an incinerator to treat the infectious waste and it is disposed off without treatment. The medical superintendent said that they have already ordered a 20kg/hr incinerator and expected to get it within two months. He also said that they are going to construct a separate room for the installation of incinerator.

The waste is disposed off outside the hospital in a municipal disposal site. The municipal site is located adjacent to G.T. road. The final disposal is done outside the Kanpur City. Upon interacting with doctors and nurses it is found that only a few of them are aware of proper waste management procedures.

For this hospital we could say that keeping the patient wards clean, removing all the waste generated within a few minutes, proper storage and final disposal is done in systematic manner. However, treatment of waste is unsatisfactory in this hospital.

Questionnaire regarding waste management is attached in Appendix-I

Waste Management Photographs of Madhuraj Nursing Home

Fig 4.3a Main building of Madhuraj Nursing Home

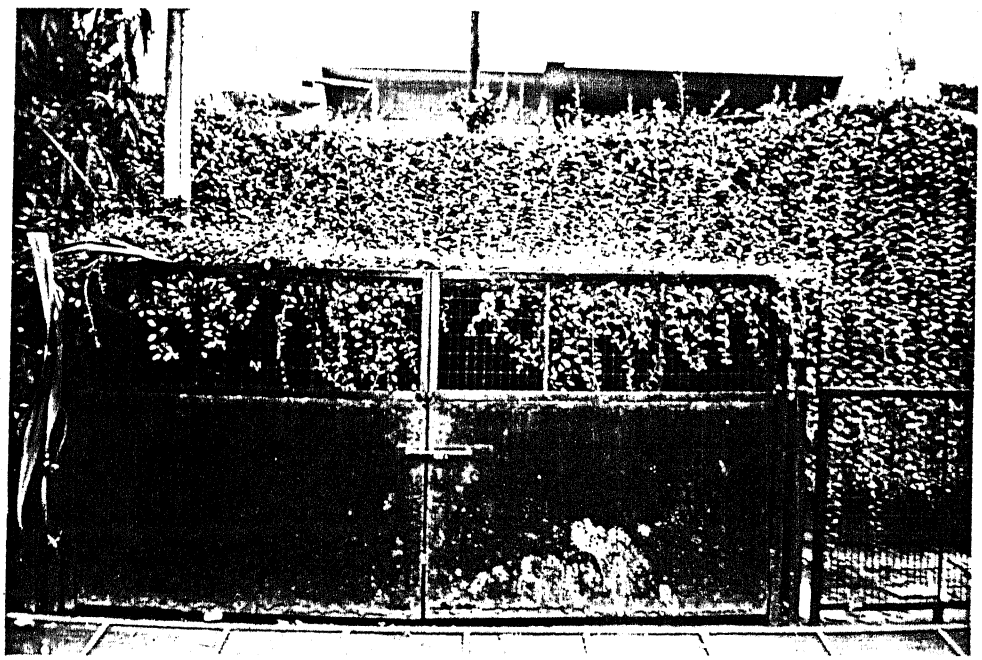

Fig 4.3.4a Waste storage site with gate

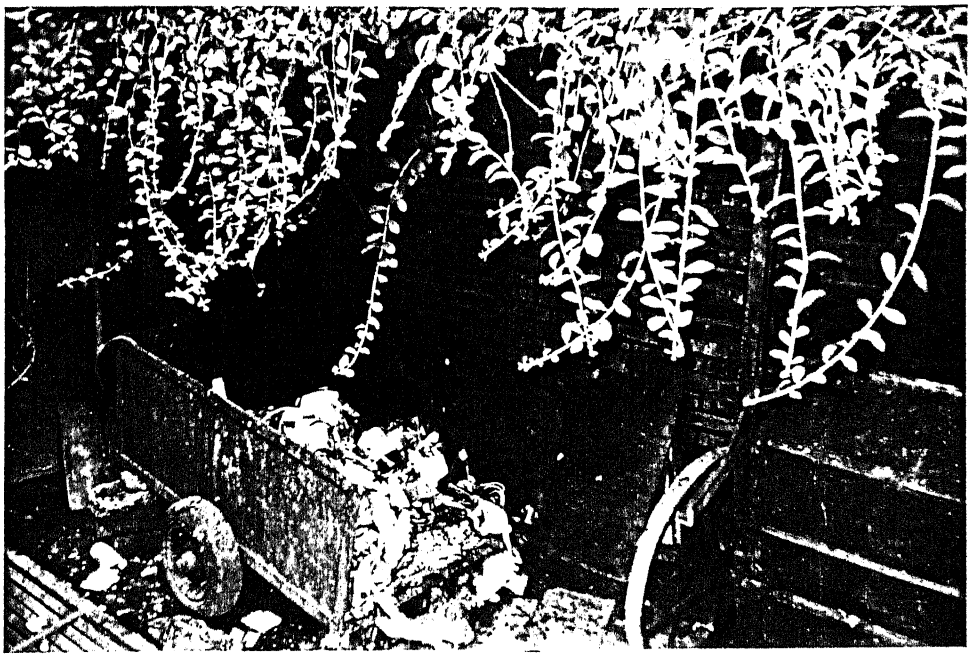

Fig 4.3.4b Waste stored in a trolley

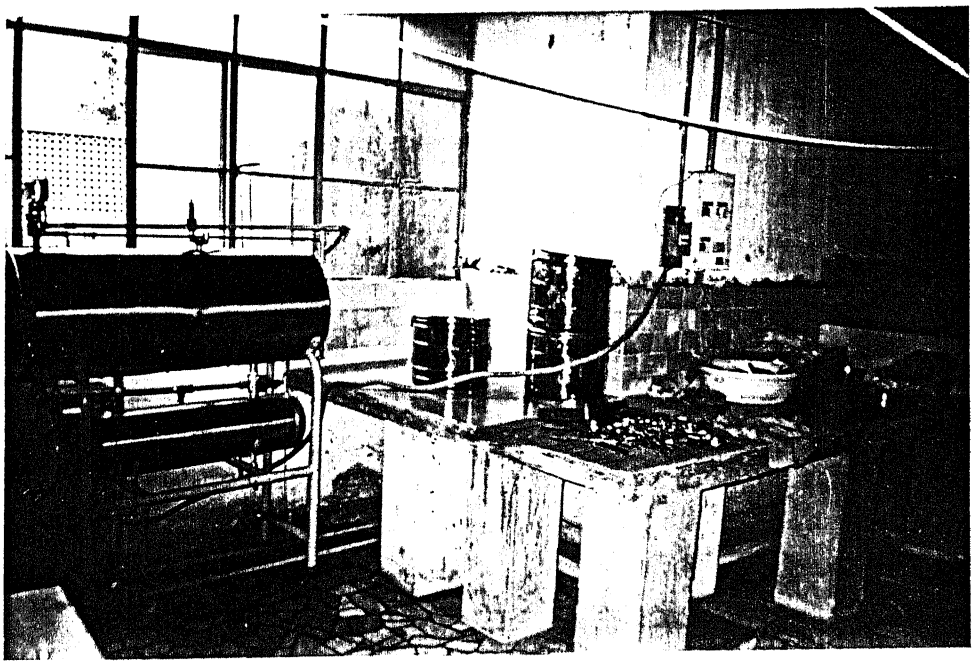

Fig 4.3.6a Autoclave used to sterilize the waste

4.4 Regency Hospital

Regency hospital is the highest rated hospital in Kanpur under private authorities'. The hospital is located in Rawatpur near the railway crossing. It is a multistoried building and consists of seven floors. This hospital was established in December 1983. The total working staff is around 400 out of which senior doctors are 65, junior doctors are 20, administration and office workers are around 100, nurses are around 100 in number, while remaining are 3rd and 4th class workers like sweepers, ward boys and sanitary workers. The hospital provides round the clock health care service to incoming patients'. The incoming patients mainly belong to industry, high-class and higher government employees. The daily OPD attendance is around 60.

For waste management in this hospital a private contractor has been appointed to oversee the proceedings. Under him 20 garbage collectors are present and they assist sanitary workers to collect, store and transport the waste generated from various areas of the hospital. The garbage gang works 3 shifts per day. According to medical superintendent the garbage gang has under gone a training for a period of 15 days in Schaum House Company at Lucknow, involving safe handling measures using protective gearing, health risks involved in their work and taking all necessary precautions.

4.4.1 Waste Generation

The hospital consists of various departments and wards like C.T. scan, X ray wing, ultrasound, ECG, lab services, pediatric lab, pharmacy, nephrology, O.P.D., emergency wings, O.T. complex, general ward and dialysis unit. The hospital also provides semiprivate patient rooms, deluxe patient rooms and super deluxe patient rooms.

The total number of beds in these wards are 115. The amount of waste generated per day is found to be 150 kg approximately, of which infectious waste is around 30 kg, noninfectious but hazardous waste is around 90 kg and remaining is non-medical and recyclable waste.

The waste material from all these departments mainly contains blood and body parts, human anatomical waste, body fluids like urine and saliva, disposable syringes and

needles, glassware, both plastic and glass bottles, laboratory waste like stocks and cultures, tissues, tumors, organs, etc.

4.4.2 Waste Collection

For waste collection, sanitary workers are employed in various floors, 8 on ground floor, 8 on first floor, 6 on third floor, 6 on fourth floor and 6 on the fifth and sixth floors. For waste collection plastic buckets and drums are used. The frequency of collection is usually thrice per day in the morning, in the afternoon and in the evening. If inpatients are more, waste is collected more than thrice. In this hospital for collection of waste the sanitary workers are provided with hand gloves, face masks and boots. Upon observation they are wearing all these protective gears and are in uniform.

4.4.3 Waste Segregation

In this hospital waste is not segregated into infectious and non-infectious waste at the source itself. Plastic buckets are provided in the ward for the collection of waste but there is no colour coding of the waste, all the waste is segregated in same plastic buckets. In operating theatres and emergency wards the waste is collected as soon as the operations are over and transported to the storage site. In this hospital also waste segregation is not upto the mark but comparatively better than the other hospitals.

4.4.4 Waste Storage

In this hospital, no separate storage facility is available for the waste. Storage is at most times unnecessary, since the amount of waste generated is not large. All the waste from various departments and wards is thrown into a big rectangular box. It is attached to a rickshaw and kept outside the hospital. The rickshaw puller takes the rickshaw far away from the hospital for disposal.

4.4.5 Waste Transportation

Trolleys are used for waste transportation from various wards to the storage site. The trolley first goes to sixth floor collects the waste and comes to the fifth floor in lift and collects the waste and similar procedure is adopted upto ground floor. Then it is taken to storage site. From storage site the rickshaw is used to carry the waste to the municipal disposal site, from there Nagar Mahapalika Van transports the waste to outside the Kanpur City.

4.4.6 Waste Treatment and Disposal

a) For the waste treatment steam sterilization and chemical disinfection methods are used.

b) Used linen is first bleached in hypochlorite solution and then autoclaved.

c) The operation theatre instruments, laboratory equipment, medical and surgical instruments are first disinfected and then steam sterilized.

d) All the wards and departments are disinfected regularly with a chemical disinfectant to remove infectious agents from contaminated surfaces.

e) Kitchen waste and left over food are disposed off along with non-infectious waste.

f) All liquid effluents are discharged into the underground sewerage system through the pipelines.

g) In the hospital there is no availability of incinerator. According to medical superintendent they have ordered a 20kg/hr incinerator, which will come within two months. For installation of incinerator they are going to provide separate location outside the hospital.

In this hospital waste management system is upto the mark in areas of collection, storage, transportation but in treatment and disposal it is not up to the expectations. The hospital authorities did not give permission to take photographs regarding waste management. Questionnaire regarding waste management is attached in Appendix-I

4.5 ANALYSIS OF OBSERVATIONS

COMPARATIVE ASSESSMENT OF WASTE MANAGEMENT AT GOVERNMENT AND PRIVATE HOSPITALS IN KANPUR.

Table 4.5

S.NO.	ITEM	LLR HOSPITAL	URSULA HOSPITAL	MADHURAJ HOSPITAL	REGENCY HOSPITAL
1	Bed strength	1055	416	80	115
2	Waste management system	A committee from housekeeping department is formed.	No system exists.	Two workers are employed.	An outside contractor is employed.
3	Man power employed for waste management	All ward sweepers and safai karmacharis are involved.	All ward sweepers and safai karmacharis are involved.	All the sweepers are involved.	20 persons under the contractor and ward sweepers are involved.
4	Average amount of waste per day(kg)	1100	550	140	150
5	Amount of infectious waste per day(kg)	200	80	30	30
6	Amount of noninfectious waste per day(kg)	650	350	80	90
7	Amount of recyclable waste per day (kg)	150	80	20	20

S.NO.	ITEM	LLR HOSPITAL	URSULA HOSPITAL	MADHURAJ HOSPITAL	
8	Way of waste collection	Plastic buckets and drums	Plastic buckets and drums.	Plastic buckets and drums.	Plastic buckets and drums.
9	Frequency of waste collection	Twice a day	Twice a day	More than twice a day	Usually thrice a day, if required, four times
10	Waste segregation.	No segregation	No segregation	No segregation	No segregation.
11	Colour coding of buckets	No colour coding	No colour coding	No colour coding	No colour coding
12	Waste storage site	An open area with out a gate is provided near the ward	An open area away from the wards but near to the main road.	A closed area in the ground floor with a gate.	A rectangular box with a cover in the ground floor.
13	Duration of storage	6 to 7 days	6 to 7 days	One day.	Few hours.
14	Transportation of waste	Only emergency and surgical wards are provided with trolleys.	Only surgical and emergency wards are provided with trolleys	Trolleys are provided	Trolleys are provided.
15	Treatment of the waste	Incineration, steam sterilization and disinfection	Steam sterilization and disinfection	Steam sterilization and disinfection.	Steam sterilization and disinfection.
16	Protective gear for hospital staff and workers.	Not provided	Not provided	Not provided	provided
17	Level of awareness among the hospital staff and workers.	Not much	Not much	Reasonable	Reasonable
18	Attitude towards waste handling	Indifferent	Indifferent	Care taken	Care taken

S.NO	ITEM	LLR HOSPITAL	URSULA HOSPITAL	MADHURAJ HOSPITAL	REGENCY HOSPITAL
19	Immunization vaccines for workers	Not given	Not given	Only O.T workers are given	Given to all the workers
20	Ragpickers entry	Collects the recyclable waste in the whole hospital	Collects the recyclable waste in the whole hospital	Not allowed	Not allowed.
21	Installation of incinerator	Installed in Dec- 1997	Not installed	Not installed	Not installed
22	Capacity of the incinerator	10 kg/hr			
23	Frequency of waste loading	Twice a day			
24	Type of waste incinerated	Cotton bandages, human anatomical waste, pathological waste and other infectious wastes.			
25	Range of operating temperature	697°C to 850°C			
26	Pollution abatement equipment	A water scrubber is installed to collect the particulate matter.			

S.NO	ITEM	LLR HOSPITAL	URSULA HOSPITAL	MADHURAJ HOSPITAL	REGENCY HOSPITAL
27	Stack height of the incinerator	30 feet above the base.			
28	Waste heat recovery of the incinerator.	Not recovered			
29	Waste storage site at the incinerator.	Not provided			
30	Fate of incinerated ash	Disposed of near the incinerator room			
31	Training to the operator	No training			
32	Protective gear for the operator.	Only hand gloves are provided, face masks and boots are not provided			
33	Security at the site of incinerator.	No security			

CHAPTER-5

DESIGN OF THE EQUIPMENT

Waste treatment ensures complete destruction of infectious agents. For treating the medical waste, various modern technologies are available as stated in literature. The best way of waste treatment is done by incineration and sterilization (autoclaving). Here both equipment is designed to fulfill the needs of hospitals in Kanpur.

5.1 Autoclave Design

Waste destruction by the method of sterilization is done in equipment called autoclave. Here infectious waste items like laboratory cultures, contaminated medical and surgical equipment, gloves, linen and facemasks are destroyed by a thermal destruction process. This process involves treatment of infectious wastes with saturated steam at sufficiently elevated temperatures to kill the infectious agents.

Proper design of an autoclave is an important factor in order to ensure complete sterilization. By sending required amount of steam into the autoclave we can operate it in safe conditions. Here design involves finding out amount of steam required to treat the waste and recommend the hospitals in Kanpur to use the same.

Data regarding autoclave was taken from Madhuraj Nursing Home.

Amount of waste material load per cycle (m_{load}) = 30 kg

Outer diametre of the autoclave (d_o) = 0.5 m

Inner diametre of the autoclave (d_i) = 0.4 m

Thickness of the autoclave (Δx) = 0.05 m

Residence time (t) = 25min

Working pressure (P) = 1.2 kg/cm^2

Operating temperature ($T_{w,inner}$) = 120°C

Length of the autoclave (l) = 1.2 m

Ambient (room) temperature (T_{amb}) = 25°C

It is assumed that the autoclave is made up of stainless steel.

Thermal conductivity of Stainless Steel at the average temperature[16] = 13.54 kcal/h-m-K

Steam side heat transfer coefficient for the autoclave[16] = 1074 kcal/h-m^2-K

Inner heat transfer area of the autoclave (A_i) = $\pi d_i l + \pi d_i^2/4$

= $\pi*0.4*1.2 + \pi*0.4^2/4$

= 1.66 m^2.

Outer heat transfer area of the autoclave (A_o) = $\pi d_o l + \pi d_o^2/4$

= $\pi*0.5*1.2 + \pi*0.5^2/4$ = 2.12 m^2.

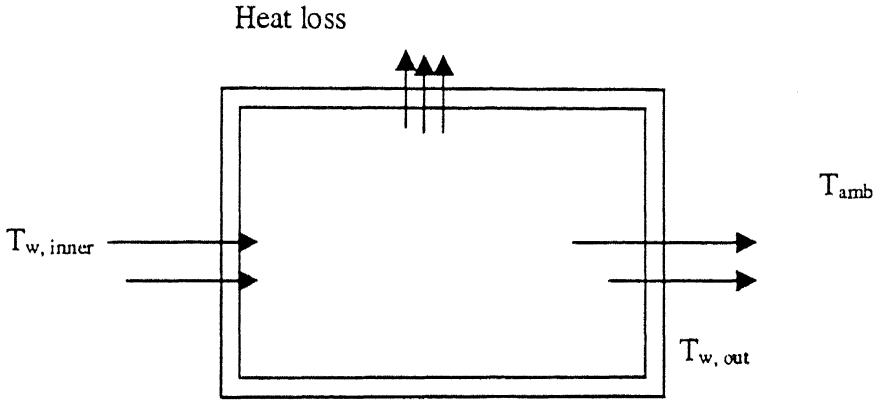

Fig 5.1 Autoclave Inner Surface

By making a heat balance over the autoclave, we can calculate the amount of steam required for treating the waste.

Heat Balance

At steady state, we have

Heat in into the autoclave = Heat out of the autoclave (5.1.1)

Heat in = Enthalpy of super heated steam + Enthalpy of contaminated equipment feed in. in

Heat out = Enthalpy of saturated steam out + Enthalpy of cleaned equipment + Heat losses

Enthalpy of Super Heated Steam in ($\Delta H_{s, in}$)

It is calculated from the formula,

$\Delta H_{s, in} = m_{steam} * H_{steam, in}$ (5.1.2)

To find $H_{steam, in}$, it is assumed that all the infectious agents get killed at 120°C.

At a pressure of 1.2 kg/cm^2 = 125 Kpa and at a temperature of 120°C,

From steam tables, $H_{steam, in} = 2724.0$ kJ/kg.

$\Delta H_{s, in} = m_{steam} * 2724$

Enthalpy of Contaminated Equipment Feed in ($\Delta H_{f, in}$)

$\Delta H_{f, in} = m_{load} * c_p * (T_{amb} - T_{ref})$ (5.1.3)

$T_{amb} = 25^{\circ}C$, assume $T_{ref} = 25^{\circ}C$.

$\Delta H_{f, in} = m * c_p (25-25)$

$= 0$

Enthalpy of Saturated Steam out ($\Delta H_{s, out}$)

It is calculated by the formula,

$\Delta H_{s, out} = m_{steam} * H_{steam, out}$ (5.1.4)

At $120^{\circ}C$ and 125 Kpa, from steam tables, $H_{steam, out} = 444$kJ/kg.

$\Delta H_{s, out} = m_{steam} * 444$

Heat Losses

To find the heat losses, we have,

Heat lost by conduction through the wall = Heat lost by convection from wall to air

$$Q = kA_i \Delta T_i / \Delta x = hA_o \Delta T_o \quad (5.1.5)$$

$$kA_i (120 - T_{w, out}) / \Delta x = hA_o (T_{w, out} - 25)$$

$$13.54 * 1.66 * (120 - T_{w, out}) / 0.05 = 1074 * 2.12 * (T_{w, out})$$

$$120 - T_{w, out} = 5.05 * (T_{w, out} - 25)$$

$$T_{w, out} = 41^{\circ}C$$

$$Q = hA_o (T_{w, out} - 25)$$

$$= 1074 * 2.12 * (41 - 25)$$

$$= 152423 \text{ kJ/hr}$$

Enthalpy of Cleaned Equipment ($\Delta H_{f, out}$)

The equipment treated contains Stainless Steel and Glass, also linen and other materials are dumped in a stainless steel can and inserted into the autoclave for decontamination.

Specific heat of Stainless Steel = $C_{p, ss}$ = 0.46 kJ/kg-°C.

Specific heat of Glass = $C_{p, g}$ = 0.84 kJ/kg-°C

Of the total mass of 30 kg, approximately 20 kg is of the S.S can and surgical equipment, the rest 10 kg is of glassware, linen, rubber gloves, etc. We take the C_p of linen, gloves to be the same as of glassware.

Thus the $C_{p, avg}$ for the S.S can and contents is

$$= (20*0.46 + 10*0.84)/30$$

$$= 0.6 \text{ kJ/kg- °C}$$

$$\Delta H_{f, out} = m_{load}*C_{p, avg}*\Delta T \quad (5.1.6)$$

$$= 30*0.6*(120-25)$$

$$= 1710 \text{ kJ/kg}$$

Heat in = Value of eqn (5.1.2) + Value of eqn (5.1.3)

$$= m_{steam}*2724 + 0$$

$$= m_{steam}*2724$$

Heat out = Value of eqn (5.1.4) +Value of eqn (5.1.5) + Value of eqn (5.1.6)

$$= m_{steam}*444 + 1710 + 152423$$

$$= m_{steam}*444 + 154133$$

∴From eqn (5.1.1)

$$m_{steam}*2724 = m_{steam}*444 + 154133$$

$$m_{steam} = 67.6 \text{ kg/h} = 1.12 \text{ kg/min.}$$

For 25 minutes residence time, the amount of steam required to treat the contaminated equipment waste = 1.12*25 = 28 kg.

So all the four hospitals must use 28 kg of steam per cycle to kill the infectious agents. If less amount of steam is used then infectious agents are not killed properly and when they are reused in operation theatres the patient can get the disease.

5.2 DESIGN OF INCINERATOR

To illustrate the concepts involved in the design of an incinerator, a problem has been chosen on the lines of the requirements of LLR Hospital in Kanpur. All unavailable data have been assumed to carry out the design[11]. It is to be mentioned as a note of caution that while performing the actual design calculations, various experiments will have to be conducted to characterize the nature of waste, its heating value, composition and amount (flow rate) of toxic gases evolved. In this problem natural gas is assumed to be auxiliary fuel, since it is expected that, with a low net heating value, the waste may not be able to sustain the heat required for its complete combustion during the entire batch time.

Design:

Total infectious waste to be incinerated in LLR Hospital = 200 kg/day.

Basis: Assuming that incinerated was operated twice a day,

1 batch capacity = 100 kg, for a residence time of 1 hour.

In 100 kg, the waste composition is,

Human anatomical waste	= 20 kg
Cotton bandage	= 40 kg
Toxic chemicals	= 30 kg
Polymer materials	= 10 kg

Physical characteristics of the waste:

Combustibles	= 50 kg
Ash	= 5 kg
Volatiles	= 45 kg

In volatiles, water present is 35 Kg and toxic chemicals present are 10 kg.

Approximate assumed elemental composition of combustibles of the waste:

Table-5.2

Name	Wt %	Wt/batch	Moles/batch
Carbon (C)	64.0	64	5.33
Water (H_2O)	5.0	5	4.96
Oxygen (O)	30.0	30	0.93
Chlorine (Cl_2)	1.0	1	-----

Waste combustion reactions are

$$C + O_2 \rightarrow CO_2$$

$$H_2 + 0.5\ O_2 \rightarrow H_2O$$

Theoretical oxygen required = 5.33 + 4.96/2

= 7.82 kg-moles/batch

= 250 kg.

Theoretical Nitrogen required = 7.82 * 0.79/0.21

= 29.4 kg-moles/batch

= 832 kg.

Theoretical air required = 250 + 832 = 1082 kg.

Assume 20 % of excess air

Air required = 1082 * 1.2 = 1300 kg.

Oxygen required = 300 kg

Nitrogen required = 1000 kg.

Unreacted Oxygen = 300 – 250 = 50 kg.

Unreacted Nitrogen = 1000 kg

CO_2 produced = 5.33 * 44 = 235 kg

H_2O produced = 35 + 4.96 * 18

= 125 kg.

Assumption:

Net heating value of waste[11] at 25°C = 4652 kJ/kg

Let the amount of natural gas used = X kg

Natural gas heating value [11]at 25°C = 45822 kJ/kg

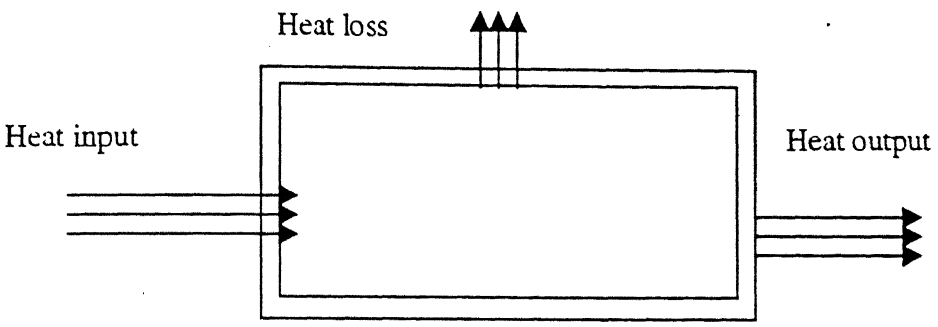

Fig 5.2 Incinerator Inner Furnace

Assume complete combustion of waste feed.

By making a heat balance over the incinerator, we have

Heat input = Heat output (5.2.1)

Heat input = Heat from waste + Heat from Natural gas (5.2.2)

= 100 * 4652 + 45822X

Heat output = Heat loss + Heat carried by product gases (5.2.3)

Heat Loss

Assume heat loss = 5 % of heat input

= 0.05 * (465200 + 45822 * X)

Heat Carried by Product Gases

= Heat carried out from product gases + heat from Natural gas (5.2.4)

Combustion products from Natural gas (CH_4):

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

CO_2 produced:

1 mole of CH_4 → 1 mole of CO_2

16 kg of CH_4 → 44 kg of CO_2

X kg of CH_4 →?

$\therefore CO_2$ produced = 2.75X kg.

From eqn (5.2.4)

Heat carried by product gases

$$= (235 + 2.75X) * 1.088 * 775$$
$$+ (125 + 2.25X) * 2.05158 * 775$$
$$+ (50 + 0.8X) * 1.088 * 775$$
$$+ (1000 + 18X) * 1.088 * 775$$
$$+ (125 + 2.25X) * 2258.0$$

From eqn (5.2.1)

Heat input = Heat output

$$465200 + 45822 * X = 0.05 * (465200 + 45822 * X)$$
$$+ (235 + 2.75X) * 1.088 * 775$$
$$+ (125 + 2.25X) * 2.05158 * 775$$
$$+ (50 + 0.8X) * 1.088 * 775$$
$$+ (1000 + 18X) * 1.088 * 775$$
$$+ (125 + 2.25X) * 2258.0$$

Upon solving above equation we get X = 45.5 kg.

Total combustion products

$CO_2 = 235 + 2.75X = 360.2$ kg

$H_2O = 125 + 2.25X = 227.5$ kg

$O_2 = 50 + 0.8X = 87$ kg

$N_2 = 1000 + 18X = 1820$ kg

Total mass of product gases = 360.2 + 227.5 + 87 + 1820 = 2495 kg

Density of product gases at 800°C = 0.3204 kg/m^3

Total volume of gas generated = V = Total mass/density

= 2495/0.3204

= 7785 m^3 for 1 hour batch operation

Assume a flow rate of gas through the stack is 1 m^3/s = 3600 m^3/hr.

If we can neglect the volume of ashes, cotton bandages and polymer materials,

we have,

Volume of incinerator = Volume of gas in the incinerator at any given time

$$= 7785./3600$$

$$= 1.972\ m^3$$

Assuming incinerator furnace is cylindrical and L/D (length to diametre) ratio is 2:1,

We have,

$$\text{Volume} = \pi * D^3/2 = 1.972$$

$$\therefore D = 1.12\ m$$

$$L = 2.24\ m$$

So the incinerator furnace should contain a diametre of 1.12m and a length of 2.24m to treat 100kg of infectious waste per batch in 1 hour.

CHAPTER-6

RECOMMENDATIONS & CONCLUSIONS.

A good hospital waste management system in the society is an important activity to stop the spreading of infectious diseases. The advent of HIV and HBV have made it imperative that hospital infection control and waste disposal system are improved. The existing loopholes as described in observations can be plugged by implementing the following recommendations to improve the waste management system in four hospitals of the city.

6.1 Recommendations

1. All the four hospitals must adopt a systematic approach- that involves the handling, storage, transport, treatment and disposal of waste by methods that can minimize risk to health and the environment.
2. The government and private hospitals must maintain official records of the amounts of waste generated in terms of infectious, non-infectious and hazardous waste per day. They should also record incinerator data about standard temperature, combustion efficiency and toxic gas emissions.
3. The two government hospitals must employ adequate number of safai karmacharis to carry the waste management. Day by day the incoming patients to the hospitals are also increasing causing more waste generation. This is a crucial factor, as the segregation of the waste has to be done properly by separation of each waste and enough persons to carry out the process.
4. For all the four hospitals, segregation of the waste at source is the key to the whole waste management process. They must implement this method accurately as incorrect classification and separation of waste leads to many problems at later stages.

5. In all the four hospitals waste should be segregated in moisture proof bags. The bags should be strong enough to resist internal or external mechanical damage and should be filled only to a level that allows the bag to be easily and tightly closed. The universal biohazard symbol must be printed on all these bags.
6. All the four hospitals must use different types of coloured bags to separate the infectious, non-infectious and hazardous wastes. The administration must take immediate action to provide these bags.
7. In all the four hospitals the size and number of the collection buckets should be appropriate to the expected amount of waste produced in the ward and easy for lifting.
8. In both Government and private hospitals pathological waste, laboratory waste and biological material left after waste, laboratory tests must be immediately disinfected by a chemical and then either disposed off safely or incinerated depending upon the waste
9. In LLR and Ursula hospitals it must be made a strict rule that waste material should not be thrown beside the wards.
10. Sharps are special kinds of waste, which can cause cuts when not properly collected and transmit infections like HIV and HBV. So all the four hospitals must put the sharp waste in containers which have appropriate decontaminants, they should be leak and puncture proof. The sharps must be disinfected and shredded before final disposal.
11. In LLR and Ursula hospitals storage facility for the waste is not appropriate. The facility should contain a compound wall, so that waste cannot spread towards the public places.
12. It must be made a strict rule in both the Government hospitals that waste should not be stored for more than two days. The hospital staff should recommend to the authorities of Nagar Mahapalika to send the van atleast once in two days to collect the stored waste for final disposal.
13. In both the Government hospitals sufficient number of trolleys should be provided for transporting the waste from different wards to the storage site.

14. In all the four hospitals, hospital staff and sanitary workers who deal with the waste must be provided with protective gears such as handgloves, face masks and boots. They should also be directed to use them when they are collecting the waste. The doctors must also wear protective gears when dealing with HIV and HBV patients.
15. In all the four hospitals, the hospital staff including doctors, nurses and the sanitary workers must be well trained and awareness created among them regarding safe handling of waste. The training will involve waste source reduction, proper collection, treatment and disposal methods. The doctors must be given training how to deal with HIV and HBV patients, as the disease transmission is very dangerous. The sanitary workers should be trained about the health effects of improper collection and disposal system. They should be made to understand the use of protective gears. The nurses should be trained how the waste is being disposed off currently, and how some of the waste is being wrongly reused.
16. The two private hospitals should avoid disposing the medical waste in the municipal disposal site.
17. Ursula, Madhuraj and Regency hospitals must install an incinerator of suitable capacity according to their infectious waste generated.
18. In LLR hospital, the installed incinerator is of very low capacity of 10kg/hr operated only couple of hours per day compared to infectious waste generated approximately 300 kg (day). They should replace the incinerator and get a new incinerator of high capacity of atleast 150 kg/day.
19. The incinerator operator at LLR hospital must be given proper training regarding the safe operation of the equipment, so as to ensure complete burning of the waste material, correct temperature standards and combustion efficiency.
20. The incinerator operator must be provided with good quality hand gloves, boots and facemask to operate the equipment. He must also be given immunization vaccines to avoid transmission of infectious diseases.
21. Maintenance and repairs of the incinerator at LLR hospital should be periodically done for its maximum efficiency.

22. The location of the incinerator is also an important factor. It should be located away from all the patient wards to minimize the effects of toxic gases emitted by incinerator.
23. The incinerator must also be operated under prescribed conditions to limit the emission of toxic gases. Also the water scrubber which is used to absorb toxic gases must be monitored frequently so that the effluent gases confirm to pollution standards.
24. The incinerator in LLR hospital must be loaded with suitable waste for which the incinerator is designed. Dumping incompatible waste into the machine must be avoided.
25. The hospital should procure a shredder to cut the hard waste material before inserting into the incinerator. It can be used for cutting syringe needles and other disposable sharps before final disposal.
26. A storage facility for the waste must be provided immediately at the incinerator site to control the spread of foul smell coming out of the waste.
27. All the hospitals must use the design specifications for the treatment of waste.

6.2 Conclusions

The following conclusions are drawn after a detailed study on the hospital waste management at four major hospitals in Kanpur City.

1. All the four hospitals do not operate systematic waste management programme.
2. Segregation of waste should be practiced by each hospital. In turn they should reduces the quantity of infectious waste generated so that disposal becomes easier.
3. Awareness of the hospital authorities should be increased regarding infectious waste management through regular workshop and training. Science institutions and voluntary organizations may come forward and organize such training programmes.
4. The most crucial factor needed for successful management of hospital waste is the knowledge and commitment of all persons involved in the process. The human element is far more important than technology. Almost any system of treatment and disposal can fail if not operated by well-trained and well-motivated staff.

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APPENDIX-I

23/7/98, 26/7/98
4/8/98.

QUESTIONNAIRE FOR HOSPITAL WASTE MANAGEMENT

1. Name and address of Hospital: Lala Lajpat Rai Hospital
near G.S.V.M Medical College, G.T. Road, Kanpur

Telephone Number: 294018

2. Total number of beds: 1055

3. Total amount of waste generated per day: 1100 kg (approximately)

Amount of infectious waste: approximately 200 kg per day
Amount of noninfectious waste: approximately 650 kg per day
Amount of recyclable waste: approximately 150 kg per day

4. Average amount of waste per bed per day: 1.05 kg

5. Sources of waste generation: Emergency wards, general & medical wards, Surgical wards, operation theatres, maternity ward, blood bank, kitchen, office rooms

6. Collection of waste:

Type of containers used:

a) Plastic drums ✓
b) Bins
c) Plastic buckets ✓ (50 kg buckets are used)
d) Plastic bags

Frequency of collection:

a) once a day
b) Twice a day ✓ in the morning and in the evening
c) More than twice

7. Types of waste generated:

a) Infectious ✓
b) Non-infectious but hazardous ✓
c) Non-hazardous ✓
d) Radioactive

8. Segregation of waste:

Site of segregation:

a) Faraway
b) Near
c) Inside ✓ (Actually separation is not done. They throw the waste besides the patient wards)

Segregation criteria:

a) Medical Vs Non-Medical
b) Infectious Vs Non-Infectious
c) Hazardous Vs Non-hazardous
d) Any other way

No criteria, all th
waste is collected i
similar type of bucke

9. Handling of waste:

Any protective gear such as hand gloves, facemasks, and boots are provided to workers for handling the waste. Not provided

10. Way of waste storage:

a) Stored in drums
b) Open storage area ✓ ge is besides the reside
c) No storage tial colony people.

Maximum duration of storage:

a) Few hours
b) One day
c) Two days
d) More than two days ✓.

usually waste is stored for 3 days, but it is found that waste is stored for about 6 to 7 days.

11. Method of waste transportation:

a) Any fixed route → NO
b) Availability of Trolleys → only few wards (emergen
c) Availability of Vehicles → nagar Mahapalika (surgical)

Waste is transported to out side Kanpur city van once in a week for final disposal and to incinerator.

12. Treatment and disposal of waste:

Methods used

a) Incineration ✓
b) Microwaving
c) Steam sterilization ✓
d) Pyrolysis or wet oxidation
e) Chemical disinfection ✓

Disposal of waste: Final disposal is outside the city. initially disposed off beside patient wards

12. Any training or education given to staff and sanitary workers regarding safe handling and disposal of waste: NO

13. Has there been any incident in the hospital when the persons have been affected adversely by the infectious waste: As the sweepers are illiterate, is they have been ~~affected they are not~~ able to tell. no information

14. If the persons involved in waste handling and treatment are given any immunization vaccines to withstand the infectious diseases: NO

15. Awareness among the hospital staff regarding waste handling, treatment and disposal methods: Not much

INCINERATOR FACILITY IN THE HOSPITAL

1. Incinerator installed? Yes
2. Date of installation: December, 1997
3. Capacity of incinerator: 10 kg/hr
4. Type of incinerator used: Electrically operated
5. Type of waste incinerated: cotton bandages, human anatomical waste, pathological waste, waste sharps & other types of infectious waste
6. Type of fuel used: no fuel is used
7. Frequency of waste loading: twice a day.
8. Temperature of primary chamber: The range is from 697°c to 850°c
9. Temperature of secondary chamber:
10. Stack height of the incinerator: 30 feet above the base
11. Air pollution control equipment: water scrubber is used to collect the particulate matter in the waste toxic gases.
12. Waste heat recovery: none
13. Disposal of incinerated ash: in disposal site, some times beside the incinerator room
14. Security at the site of incinerator: no security
15. Any training given to incinerator operator: no
16. Protective equipment for the operator: only gloves are given face masks & boots are not given

5/6/98.
7/8/98.

QUESTIONNAIRE FOR HOSPITAL WASTE MANAGEMENT

1. Name and address of Hospital: Ursula Horsman Hospital
   Near Bada Chowrah, G.T Road. kanpur.

   Telephone Number: 311144

2. Total number of beds: 416

3. Total amount of waste generated per day: approximately 550 kg

   Amount of infectious waste: approx. 80 kg/day
   Amount of noninfectious waste: approx. 350 kg/day
   Amount of recyclable waste: approx: 80 kg/day.

4. Average amount of waste per day: 1.3 kg (Per bed)

5. Sources of waste generation: operation theatres, Pathology, general medical wards, surgical ward, mat. emergency ward, burn ward, kitchens, office rooms, storage rooms, etc.

6. Collection of waste:

   Type of containers used:

   a) Plastic drums ✓
   b) Bins
   c) Plastic buckets ✓ (40 kg buckets are used)
   d) Plastic bags

   Frequency of collection:

   a) once a day
   b) Twice a day ✓ (morning & evening)
   c) More than twice

7. Types of waste generated:

   a) Infectious ✓
   b) Non-infectious but hazardous ✓
   c) Non-hazardous ✓
   d) Radioactive

8. Segregation of waste:

   Site of segregation:

   a) Faraway ✓ far away but near the main road, mat too waste is not separated but thrown away after collection
   b) Near
   c) Inside

Segregation criteria:

a) Medical Vs Non-Medical
b) Infectious Vs Non-Infectious
c) Hazardous Vs Non-hazardous
d) Any other way

criteria
No segregation at the site of waste generation.

9. Handling of waste:

Any protective gear such as hand gloves, facemasks, and boots are provided to workers for handling the waste. Not given

10. Way of waste storage:

a) Stored in drums
b) Open storage area ✓ (adjacent to the main road)
c) No storage

Maximum duration of storage:

a) Few hours
b) One day
c) Two days
d) More than two days ✓ (for 6 to 7 days. waste is coming onto main road)

11. Method of waste transportation:

a) Any fixed route – no
b) Availability of Trolleys → only few wards
c) Availability of Vehicles → (Nagar Mahapalikavan)

Waste is transported to Outside the city for final disposal.

12. Treatment and disposal of waste:

Methods used

a) Incineration
b) Microwaving
c) Steam sterilization ✓
d) Pyrolysis or wet oxidation
e) Chemical disinfection ✓

Disposal of waste: storage site is open dispersal site inside hospital. final disposal is outside the city.

12. Any training or education given to staff and sanitary workers regarding safe handling and disposal of waste: No

13. Has there been any incident in the hospital when the persons have been affected adversely by the infectious waste: one or two incidents, affected by viral fever.

14. If the persons involved in waste handling and treatment are given any immunization vaccines to withstand the infectious diseases: not given

15. Awareness among the hospital staff regarding waste handling, treatment and disposal methods: not much

INCINERATOR FACILITY IN THE HOSPITAL

1. Incinerator installed? Not installed. They have ordered for a 20 kg/hr incinerator
2. Date of installation: _____
3. Capacity of incinerator: _____
4. Type of incinerator used: _____
5. Type of waste incinerated: _____

Medical superintendent said that it has to come from Lucknow. Government is delaying.

6. Type of fuel used: _____
7. Frequency of waste loading: _____
8. Temperature of primary chamber: _____
9. Temperature of secondary chamber: _____
10. Stack height of the incinerator: _____
11. Air pollution control equipment: _____

12. Waste heat recovery: _____
13. Disposal of incinerated ash: _____
14. Security at the site of incinerator: _____
15. Any training given to incinerator operator: _____
16. Protective equipment for the operator: _____

10/7/98,
4/8/98,

QUESTIONNAIRE FOR HOSPITAL WASTE MANAGEMENT

1. Name and address of Hospital: Madhuras Nursing Home
Swaroop nagar, Mchi Seel, Kanpur.

Telephone Number: 292344, 292346

2. Total number of beds: 80

3. Total amount of waste generated per day: approx: 140 kg

Amount of infectious waste: approx: 30 kg/day
Amount of noninfectious waste: approx: 80 kg/day
Amount of recyclable waste: approx: 20 kg/day.

4. Average amount of waste per day: 1.75 kg. (bed per)

5. Sources of waste generation: nursing stations, operation theatres, surgical ward, pathological labs, general patient wards, kitchens and dram office rooms

6. Collection of waste:

Type of containers used:

a) Plastic drums ✓
b) Bins
c) Plastic buckets ✓ (25 kg each)
d) Plastic bags

Frequency of collection:

a) once a day
b) Twice a day
c) More than twice ✓ (if required 3 4 to 5 times)

7. Types of waste generated:

a) Infectious ✓
b) Non-infectious but hazardous ✓
c) Non-hazardous ✓
d) Radioactive

8. Segregation of waste:

Site of segregation:

a) Faraway
b) Near
c) Inside

} Not segregated,

Segregation criteria:

a) Medical Vs Non-Medical
b) Infectious Vs Non-Infectious
c) Hazardous Vs Non-hazardous
d) Any other way

No criteria is employed operation theatre waste is dumped into general waste bucket

9. Handling of waste:

Any protective gear such as hand gloves, facemasks, and boots are provided to workers for handling the waste. Not given

10. Way of waste storage:

a) Stored in drums
b) Open storage area
c) No storage

Stored in a closed area in ground floor, it also has a gate

Maximum duration of storage:

a) Few hours
b) One day ✓
c) Two days
d) More than two days

11. Method of waste transportation:

a) Any fixed route → no
b) Availability of Trolleys → yes
c) Availability of Vehicles → no

Waste is transported to storage site and to the disposal site, which is adjacent to NH road,

12. Treatment and disposal of waste:

Methods used

a) Incineration ✗
b) Microwaving
c) Steam sterilization ✓
d) Pyrolysis or wet oxidation
e) Chemical disinfection ✓

Disposal of waste: waste is initially disposed off in a municipal disposal site from there Nagar m. can transport to outside

12. Any training or education given to staff and sanitary workers regarding safe handling and disposal of waste: No training

13. Has there been any incident in the hospital when the persons have been affected adversely by the infectious waste: no incident

14. If the persons involved in waste handling and treatment are given any immunization vaccines to withstand the infectious diseases: The people in operation theatre are given,

15. Awareness among the hospital staff regarding waste handling, treatment and disposal methods: Reasonable

INCINERATOR FACILITY IN THE HOSPITAL

1. Incinerator installed? Not installed. The medical superintendent said
2. Date of installation: ____ that they have ordered
3. Capacity of incinerator: ____ for a 20 kg/hr incinerator
4. Type of incinerator used: ____ it is expected to come
5. Type of waste incinerated: ____ in two months

6. Type of fuel used: ____
7. Frequency of waste loading: ____
8. Temperature of primary chamber: ____
9. Temperature of secondary chamber: ____
10. Stack height of the incinerator: ____
11. Air pollution control equipment: ____

12. Waste heat recovery: ____
13. Disposal of incinerated ash: ____
14. Security at the site of incinerator: ____
15. Any training given to incinerator operator: ____
16. Protective equipment for the operator: ____

QUESTIONNAIRE FOR HOSPITAL WASTE MANAGEMENT

5/8/95.

1. Name and address of Hospital: Regency Hospital.
near Railway Crossing, Rawatpur, kanpur

   Telephone Number: 295789

2. Total number of beds: 115

3. Total amount of waste generated per day: approx: 150 kg

   Amount of infectious waste: approx: 30 kg/day
   Amount of noninfectious waste: approx: 90 kg/day
   Amount of recyclable waste: approx 20 kg/day.

4. Average amount of waste per day: 1·30 kg (bed per)

5. Sources of waste generation: operation theatres, general and medical wards, surgical wards, nursing stations, blood banks, laboratories, kitchens and office rooms.

6. Collection of waste:

   Type of containers used:

   a) Plastic drums ✓
   b) Bins
   c) Plastic buckets ✓
   d) Plastic bags

   Frequency of collection:

   a) once a day
   b) Twice a day
   c) More than twice ✓ (usually 3 time of incoming patients are more four time).

7. Types of waste generated:

   a) Infectious ✓
   b) Non-infectious but hazardous ✓
   c) Non-hazardous ✓
   d) Radioactive

8. Segregation of waste:

   Site of segregation:

   a) Faraway
   b) Near
   c) Inside

   } no segregation of waste.

Segregation criteria:

a) Medical Vs Non-Medical
b) Infectious Vs Non-Infectious
c) Hazardous Vs Non-hazardous
d) Any other way

} no criteria is involved. All the waste is dumped int similar type of bucke

9. Handling of waste:

Any protective gear such as hand gloves, facemasks, and boots are provided to workers for handling the waste. Yes, provided

10. Way of waste storage:

a) Stored in drums ✓, a rectangular box
b) Open storage area provided in the ground flo
c) No storage

Maximum duration of storage:

a) Few hours ✓
b) One day
c) Two days
d) More than two days

11. Method of waste transportation:

a) Any fixed route no
b) Availability of Trolleys - yes
c) Availability of Vehicles → A Rickshaw is available

Waste is transported to Muncipal disposal site, far away from the hospital.

12. Treatment and disposal of waste:

Methods used

a) Incineration
b) Microwaving
c) Steam sterilization ✓
d) Pyrolysis or wet oxidation
e) Chemical disinfection ✓

Disposal of waste: _____

12. Any training or education given to staff and sanitary workers regarding safe handling and disposal of waste: Yes given; in a Schaum Holye company.

13. Has there been any incident in the hospital when the persons have been affected adversely by the infectious waste: no

14. If the persons involved in waste handling and treatment are given any immunization vaccines to withstand the infectious diseases: yes

15. Awareness among the hospital staff regarding waste handling, treatment and disposal methods: reasonable

INCINERATOR FACILITY IN THE HOSPITAL

1. Incinerator installed? no. The M. superintendent said that, they
2. Date of installation: _____ have ordered for a
3. Capacity of incinerator: _____ 20 kg/hr incinerator
4. Type of incinerator used: _____ and is expected to
5. Type of waste incinerated: _____ come within 3 mo

_____

6. Type of fuel used: _____
7. Frequency of waste loading: _____
8. Temperature of primary chamber: _____
9. Temperature of secondary chamber: _____
10. Stack height of the incinerator: _____
11. Air pollution control equipment: _____

12. Waste heat recovery: _____
13. Disposal of incinerated ash: _____
14. Security at the site of incinerator: _____
15. Any training given to incinerator operator: _____
16. Protective equipment for the operator: _____

APPENDIX-II

Hospital washes hands off as doctor gets AIDS

By Rashme Sehgal

MEERUT: The first Indian doctor to have got infected with AIDS virus has been forced to go underground. This brilliant gold medalist, a chief resident doctor in King George's Medical College (KGMC) in Lucknow, claims he was a victim of a needle injury. But the senior medical fraternity in the hospital have deliberately hushed up the case and blamed him for having loose sexual morals.

KGMC is the only hospital in UP treating AIDS patients. But junior doctors working here insist that disposable syringes are seldom used and even gloves are not provided while handling blood samples of AIDS patients. Glass syringes continue to be used for injections for as many as 20 to 30 patients at a stretch and are then put into a boiler for disinfection.

This shocking case shot into prominence some months ago when junior doctors in this hospital were up in arms against reports that a doctor and a junior house officer had got HIV-infection. In the second case also, the officer received a needle prick injury. When he approached the hospital authorities for prophylactic treatment, he was cold-shouldered. These two cases sent shock waves in the medical fraternity with questions being asked in the Vidhan Sabha.

But the above mentioned doctor, (whose name has been deliberately concealed) frightened of being ostracised and realising the adverse publicity could ruin his career, resigned from the hospital and has chosen to find a job abroad.

His young colleagues are incensed with the way his case was handled. Dr Asha Mehra, professor of pathology at the KGMC vouches for an alarming increase in HIV-infected patients coming in for treatment.

Mehra says, "HIV positivity has risen dramatically during the last five years. Last year alone more than half the cases, amounting to 57 in number, belonged to the high risk category of blood donors, STD patients, homosexuals and foreigners. They were horrified when they learnt they had HIV-infection."

This doctor was also traumatised when he tested positive.

His elderly parents who live in a village near Meerut insisted he go to the National AIDS Research Centre in Pune to get a second opinion. There, too, he tested HIV positive.

His father, a retired government engineer said, "We accosted Dr A R Sarkar, professor of medicine at the KGMC with the facts. He sidestepped us by wanting our son to go in for surgery. When is surgery known to cure AIDS ? When we refused, he simply washed his hands off this case."

His mother said, "Initially my son lost five kilos of weight but now that he is taking the AZT drug, he has put on weight. We have been giving him money every month to help him buy this drug in the black market. Do the KGMC authorities have some responsibility towards him by helping him buy this expensive drug?" she wondered.

They are happy that earlier he was required to get his blood tested every month but now he can get the test done once in six months. The mother admitted, "No one in our village knows about his illness, not even our close relatives. The minute they will come to know, our entire family will be ostracised."

Dr Sarkar at the KGMC denied that deliberate negligence had resulted in the hospital staff having contracted AIDS.

"Doctors are given disposable syringes and all proper precautions are taken. The problem is that AIDS is spreading amongst all sections of society."

He refused to discuss the case of the doctor having acquired AIDS claiming that National AIDS Control Organisation (NACO) had given the hospital a clean chit. Mr J V R Prasad, project director of NACO insisted, "We have conducted an independent enquiry. Dr A Sengupta, an independent consultant was sent to Lucknow. He submitted a report that the doctor got AIDS because he had bad morals."

The Indian EXPRESS
NEW DELHI ■ FRIDAY ■ AUGUST 1, 1997

Order for safe disposal of hospital waste soon

DAMANDEEP SINGH
NEW DELHI, JULY 31

THE Ministry of Environment and Forests is giving final touches to a notification regarding disposal of bio-medical waste generated by hospitals, clinics, research and development organisations, laboratories and slaughterhouses.

This notification has been hanging fire for the past two years. It will lay down procedures for disinfection, treatment and disposal of bio-medical waste.

The Supreme Court had in 1995, following a PIL, asked the Central Government to install incinerators in all hospitals and nursing homes in the Capital which have more than 50 beds.

Since then several studies have shown that lack of facilities for disposal of medical waste and improper use of incinerators in the mushrooming nursing homes and hospitals are posing a major environmental problem.

Most hospitals and nursing homes in the capital — surveyed by an environmental NGO — have no disposal system of their own and depend on the municipal corporation to dispose of their garbage.

The notification, which is expected in September, will specify categories of bio-medical waste, types of containers to be used, labels required and options for treatment and disposal. The rules, to be known as the Bio-Medical Wastes (Management and Handling) Rules, will be issued under various sections of the Environment Protection Act, 1986.

Water contamination

MEDICAL waste, including hazardous incinerator ash, is dumped in landfills without lining to contain toxicity for some time. There are several latent health hazards associated with such disposal. Diseases like hepatitis can occur through ground water contaminated by such infectious waste.

The rules will apply to wastes like human anatomical wastes, blood and body fluids, animal wastes, waste sharps (needles, syringes, scalpels etc), highly infections wastes, isolated wastes, discarded medicines, discarded glassware, soiled wastes, liquid wastes, biotechnology wastes, slaughterhouse wastes and incineration wastes.

Soiled cotton, dressings, linen bedding outdated, contaminated and discarded medicines and ash from incineration of bio-medical wastes are also included in the schedule of wastes covered under the rules.

Biotechnology wastes are genetically-engineered organisms or products and their cultures not declared to be safe. These include wastes from laboratory culture, stocks or specimens of micro-organisms, live or attenuated vaccines, human and animal cell culture used in research and infection agents from research and industrial laboratories, dishes and devices used to transfer cultures.

An important feature of these rules will be prohibition of import and export of such wastes. In order to track these wastes, the bi-annual reports, maintenance of records and annual returns will be made mandatory.

The rules will make appropriate officials responsible for the task of implementing them. All persons handling such wastes will be required to obtain authorisation.

Segregation of wastes at the

Recycling of disposable syringes may spur AIDS

By Sanjay Singh
The Times of India News Service

KANPUR: The problem of discarded needles and syringes has acquired a serious dimension with a recent study revealing that in Hissar, Haryana, over 56 per cent of the syringe samples collected from chemists, were used ones. Some estimates peg the figure at 20 per cent of all syringes available with chemists.

Despite instructions by experts and the administration's claim of taking necessary steps to put an end to the pernicious practice, the problem remains intractable, immeasurbly increasing the potential of AIDS and hepatitis-B cases.

'Disposable needles' itself seems to have become a misnomer, as they are surreptitiously recycled and end up with chemists, for resale in the market. None of the hospitals here has maintained any record of the number of needles crushed, to prevent resuse. Needle-syringe crusher may be a solution which is being used successfully in various metropolitian hospitals, across the country.

Seriously compounding the problem is the lack of incerinators at hospitals. "There is parallel economy which mints crores by reusing syringes and needles, which have should have been destroyed before disposal," Dr B K Singh, chief medical superintendent of Kanpur Medical College Hospital observed.

In Kanpur for instance, removal of hospital wastes is often assigned to private contractors, who dump the collection at a particular spot. The hospital superintendent said the staff has been asked to destroy syringes after use.

But the availability of these syringes in large numbers tells a different story. The staff members of the lower rung are seemingly flouting the instructions in this regard. Many of them are said to be hand in glove with those running this parallel business.

The fact remains that several doctors do not take full precautions in this regard says Dr Laxmi Arya. The crusher is made of polypropane and has metal parts of stain less steel. The makers claim that it can destroy up to 10,000 needles and syringes at one go. The present model is essentially designed for general practitioners, dentists and pathological labs. However it is being used effectively in the hospital wards.

Many doctors complain that they had at some time or the other received stocks of used disposable needles. One doctor said "I have stock of needles which I use only for family my members and close associates." According to the World Health Organisation Estimate, their all over eight million carriers of Hepatitis-B in India.

Around three million HIV positive cases are expected to flood the country by the turn of the century. Just a few drops of infected blood can cause AIDS and Hepatitis-B.

Dangerous Waste

EVEN as the modern world takes to newer and safer modes of medical waste disposal, government hospitals and private nursing homes in Delhi continue to flout even those safety norms which are by far dated. Most city hospitals are without incinerators, despite the Supreme Court directives, and continue to litter the city with much that ought not to be there.

By one conservative estimate, Delhi hospitals with 70,000 bed capacity generate nearly 70 tonnes of medical waste per day. Of this, 35 tonnes is highly infectious. If cast away without treatment, it threatens to spread many deadly diseases. Yet, only a few major hospitals have installed small incinerators; others continue to dump their waste at municipal bins or at one of the many sanitary land fill sites, maintained by the civic body on the city's outskirts. Even these sites pose serious health hazards to the nearby colonies and villages and to the rag pickers who walk barefoot to collect what they can from the dump for recycling purposes. The use of incinerators cannot guarantee against toxic gas emissions. The new microwave technology may hold the hope. Experts claim it disinfects the waste completely; there is no oxidation or decomposition. At the exit point, the treated waste is reduced by about 80 per cent in volume and is disinfected of all bacterial spores, fungi and other infectious components. The 'waste of waste' holds the potential to be recycled for power generation. The operational cost of microwav technology is also far less than wh is the conventional method entails.

This safer, environmentally sound alternative was approved by the Central Pollution Control Board some time ago, and should have been introduced at Delhi hospitals by now. But as things stand, even the Timarpur plant, which was expected to tackle all the waste from land-fill sites, is lying inoperational for want of repairs.

Neelabh

Sloppy rules let racket thriving

By Anju Sharma

NEW DELHI, April 11

Due to lax rules governing hospital waste management in Delhi Government hospitals, a major racket in recycling of disposable like syringes and glucose bottles is thriving. So be careful the next time you walk into a hospital for an injection. For you may get AIDS virus, hepatitis, tetanus or typhoid from the harmless looking syringes. For the nicely packed syringe may have originated from the garbage dump of the same hospital.

A major racket has come to light in the recycling of items like syringes. The culprits been ragpickers and even hospital *karamcharis.*

The filth in the hospitals confirms one fact: There is no organised system for disposing of the hospital waste. Littered bandages, blood-soaked cotton swabs, gloves and stinking toilets have literally transformed hospitals into garbage dumps.

Even though a year has passed after the Supreme Court issued orders on the medical waste disposal, no attention has been paid by the authorities to this vital aspect of health care.

Despite strictures from the Apex Court on the medical waste disposal, no person or department has been made accountable for this purpose.

The hospitals seem to have done their duty by the installation of incinerators. In March 1996 in response to a public interest litigation, the Apex Court ordered that all hospitals with over 50 beds in the Capital should have an incinerator. But when environmentalists mentioned about the harmful effects of incinerators, the order was changed to either incinerators or other alternate technologies.

So crores have been spent on the installation of incinerators in all city hospitals. But a doctor of LNJP says, "What is the use of the incinerators? The garbage continues to be scattered all over the hospital."

In fact, the report of the Comptroller and Auditor General of India, which was tabled in the Delhi Assembly recently, has puled up the LNJP administration for not utilising the incinerator. The report says, "on the recommendation of the Hospital Acquired Infection Control Committee, the hospital purchased eight mini-incinerators, worth Rs 36,000 in February, 1994 but failed to install any of them.

The hospital has continued to employ trucks to clear the garbage despite having bought an incinerator, a practice which entails serious risk of infection. The hospital was quick to buy a prolytic incinerator in April, 1993 which was awaiting installation as its layout plans had not been approved by the MCD."

The situation is similar at the Rajen Babu Tuberculosis Hospital. The hospital has been recently under fire for not using their incinerator. The garbage was been carried by NDMC trucks though lot of money had been spent on buying the incinerator.

Even a visit to the hospital reveals that a concept like 'waste management' has been unheard here. Disposed syringes, bandages, glucose bottles and blood-stained sheets are dumped in the corner of the hospital. A doctor says, "the incinerator is rarely used. The waste is dumped. Sometimes trucks come to lift the garbage. "Due to these pathetic conditions, the patients are at a great risk.

But most hospitals are sleeping over the issue of recycling of hospital waste. The special favourite of those involved in this racket are syringes. There is a ready market for these syringes. The rate been Rs 80 kg. The modus operandi used by the people involved is simple. The place to watch is the garbage dumps outside major hospitals.

Around 5 a.m., even before the MCD vans come, the ragpickers are on their job hunting for recyclable items. When the garbage vans arrive, these 'syringe stealers' disappear. By the morning they are selling their 'booty' in markets in Ballabgarh, Meerut, sunday bazars near Delhi.

A senior health official in the Delhi Administration admitted that the syringes are openly being sold in district hospitals and even reputed private clinics. "Though all hospitals have incinerators but majority are not using them. So the risk of the syringes finding their way back into the same hospital is high", he said.

However, he maintained that the risk of recycled syringes being used was higher in smaller district hospitals." But the possibility of the recycled syringes being sold in Government hospitals cannot be ruled out," he added.

STATE OF THE CAPITAL

HOSPITAL WASTE MANAGEMENT